The magazine of aerospace technologies / JUNE 1960

# space aeronautics

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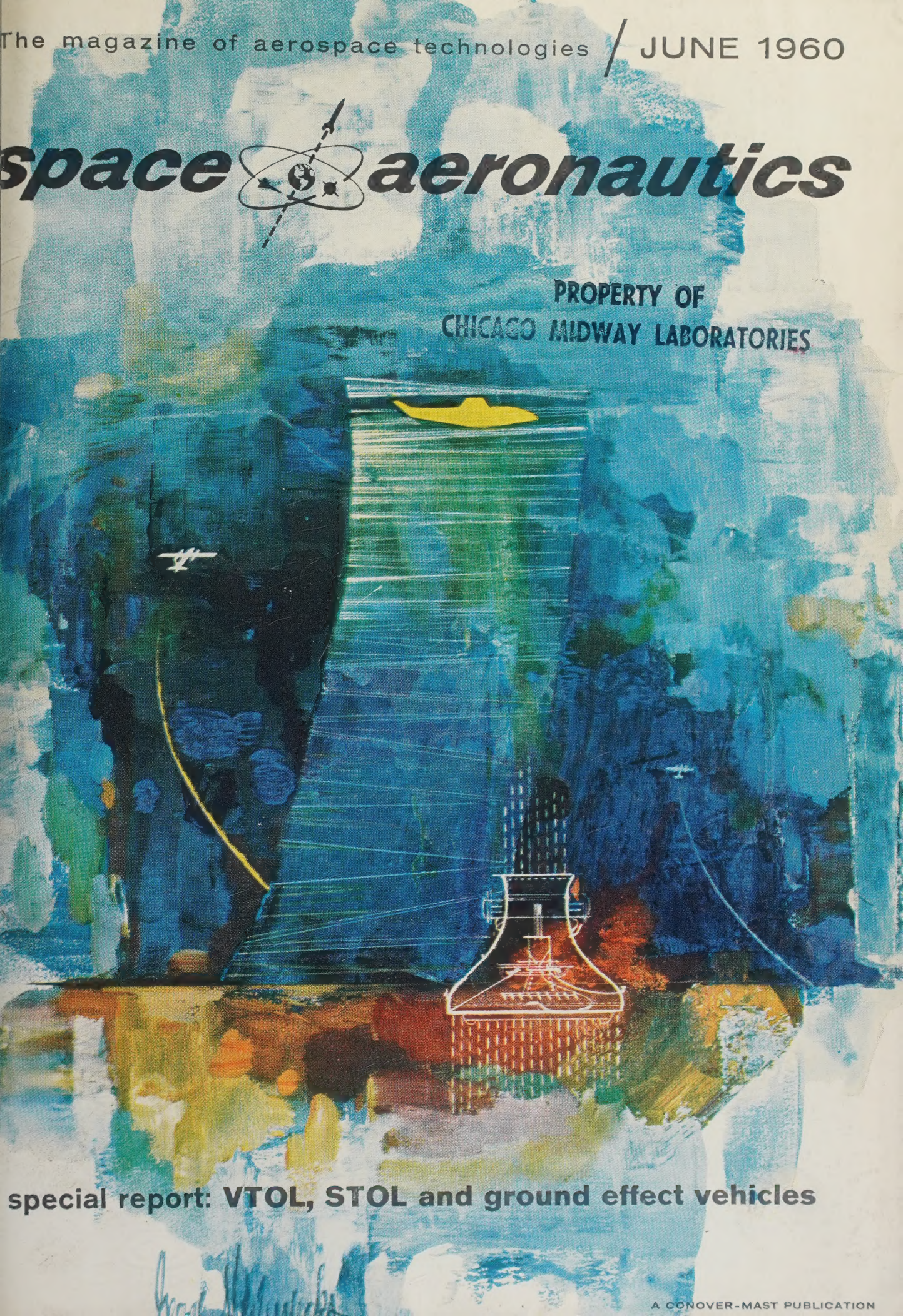

special report: VTOL, STOL and ground effect vehicles

A CONOVER-MAST PUBLICATION

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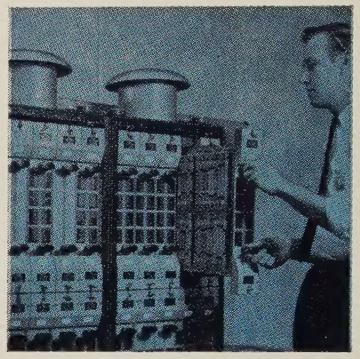
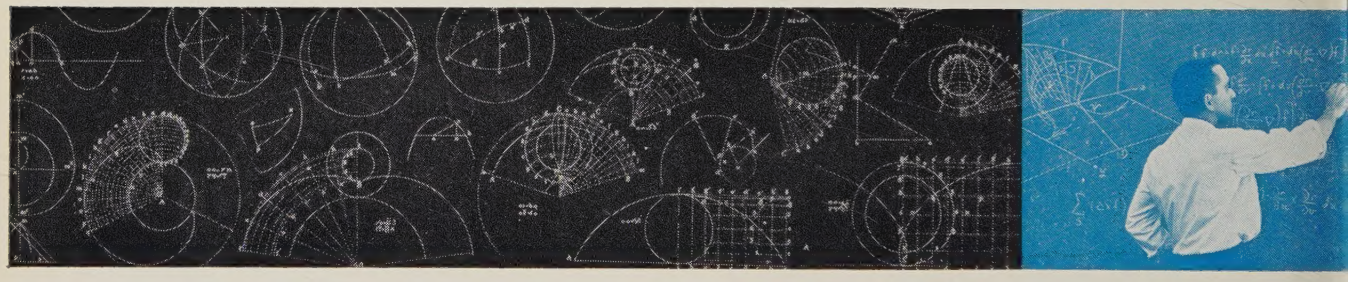
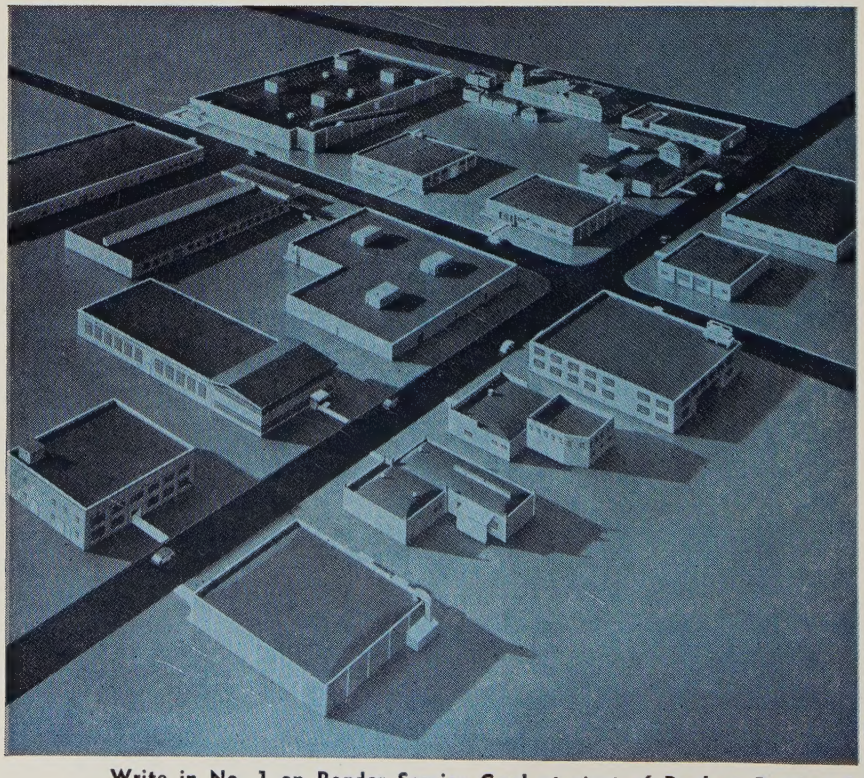




*computers that pace man's expanding mind*



GP

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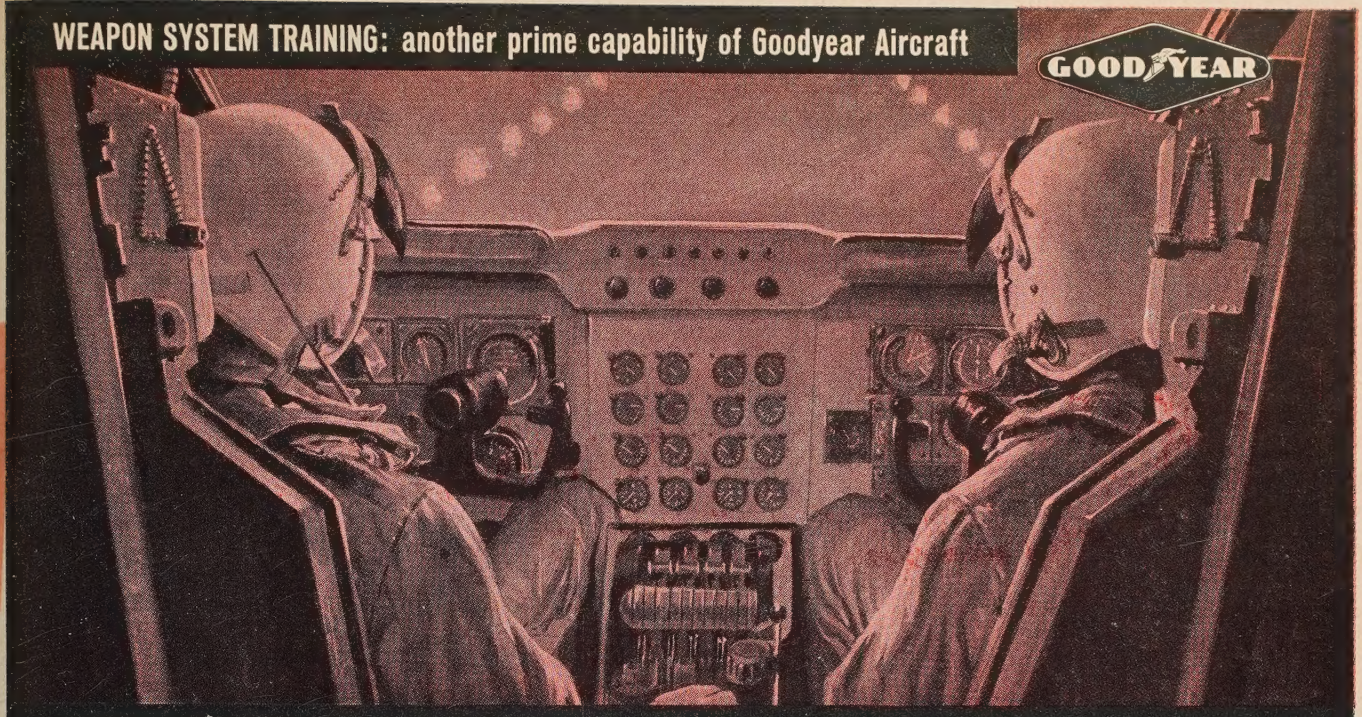
## WEAPON SYSTEM TRAINING: another prime capability of Goodyear Aircraft

GOODYEAR



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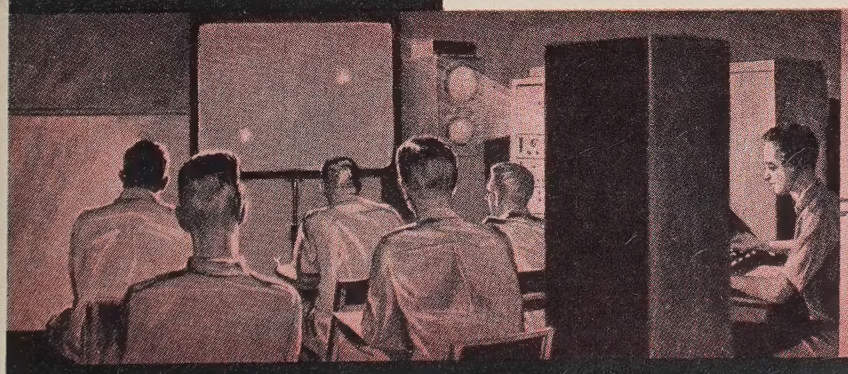
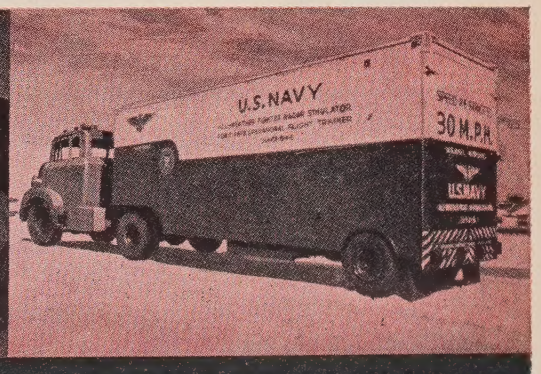


**Classroom trainer, radar target generator** — also available at GAC.




**Mobile flight simulator** — built by GAC for Navy.

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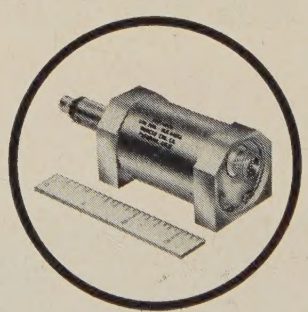

Further information contained in EDS 699 & Product Bulletin 108A

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space/aeronautics

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Published monthly (except semi-monthly in June) by Conover-Mast Publications, Inc. Editorial and Executive Offices: 205 E. 42nd Street, New York 17. Single copy $1.00 except special issues. Subscription U. S. A. $10.00 annually; Canada, $15.00 annually; Other foreign $20.00 annually. Printed by Periodical Press Corp., Phila. 40, Pa. Accepted as controlled circulation publication at Philadelphia, Pa., New York, N. Y.



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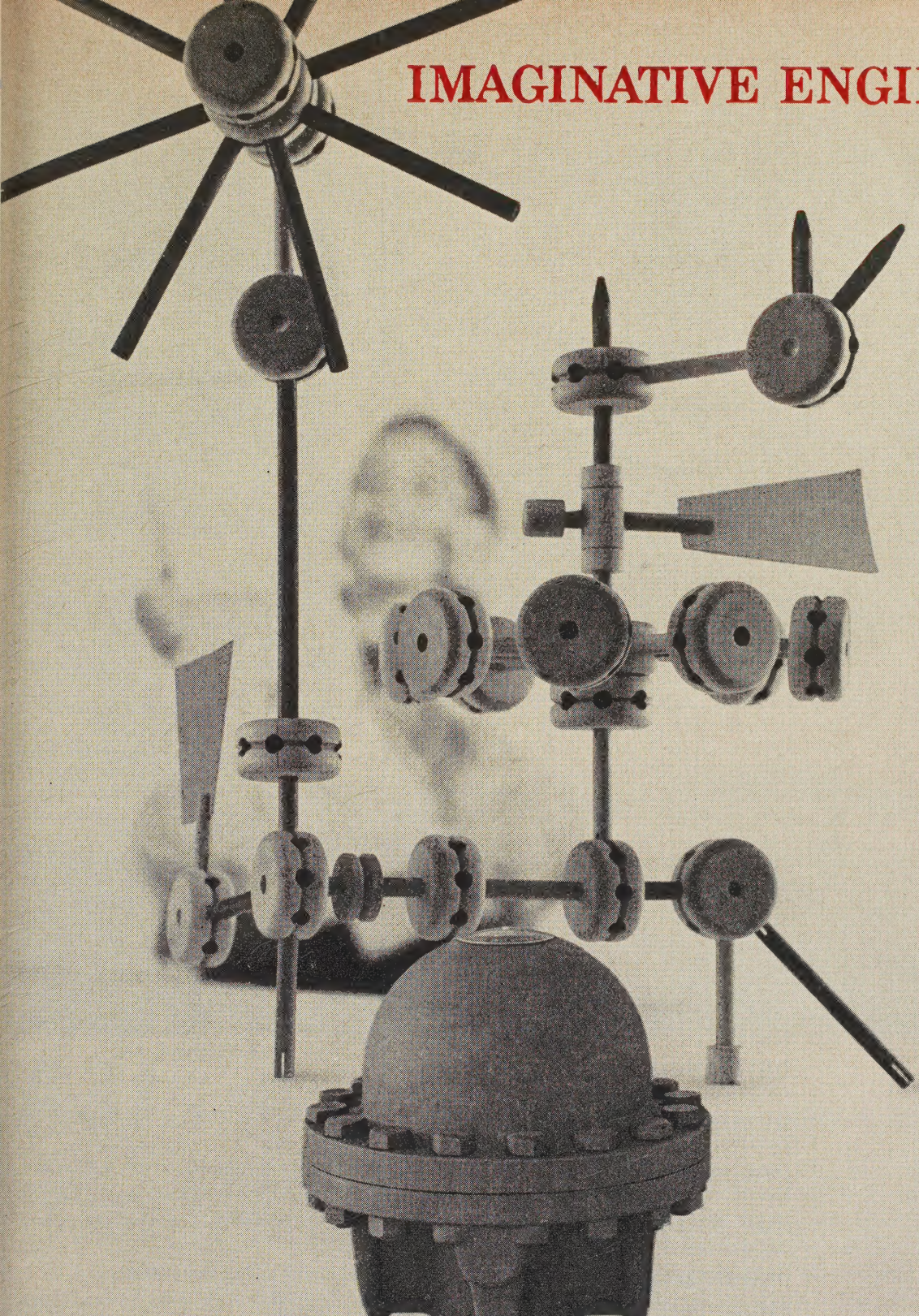
# IMAGINATIVE ENGINEERING



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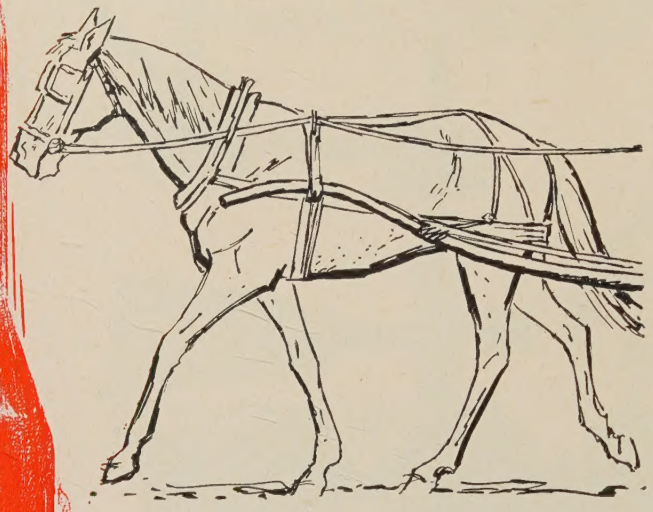

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## cover story

The magazine of aerospace technology / JUNE 1960
space/aeronautics
special report: VTOL, STOL and ground effect vehicles

**Hugging** the earth and getting away from it quickly—these two principles of ground effect and V-STOL flight are shown on our cover by artist George Meyerriecks. How these principles work out in application is shown in the special report on "VTOL, STOL and Ground Effect Vehicles," beginning on *page 43*. This report consists of an analysis of the market for these "unconventional" craft and its probable development, reviews of the state of the art in GEMs and V-STOLs, and extensive listings of specifications and performance data for the vehicles now in production or development.


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# A3J—*the most versatile Mach 2 airplane in the world today*

Probing the horizons of the Free World, hovering on the fringes of tension areas, bolstering the cause of world peace by its mere presence in the sky—this is the job for the Navy's new A3J Vigilante.

Designed and built by the Columbus Division of North American Aviation, the A3J has a versatility unmatched by any other Mach 2 airplane in the skies today. It is equipped to handle a variety of nuclear or conventional weapons for either limited or all-out nuclear war. It has the speed and maneuverability to fly single-plane attack missions without fighter escort.

The Vigilante can fly through the stratosphere faster than the earth turns beneath it; yet can throttle down to comfortable landing speeds for carrier decks—or small fields ashore. It is also notable for prompt response characteristics that make it ideally suited for low-level missions over irregular terrain. Its speed and maneuverability plus the most advanced fire control systems known make it a single airplane with an outstanding dual capability—high-performance attack or long-range interception.

The A3J Vigilante truly is a significant addition to the U. S. arsenal dedicated to preserving world peace.

**THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.**

Columbus, Ohio

June 1960

space aeronautics

volume 33, number 6

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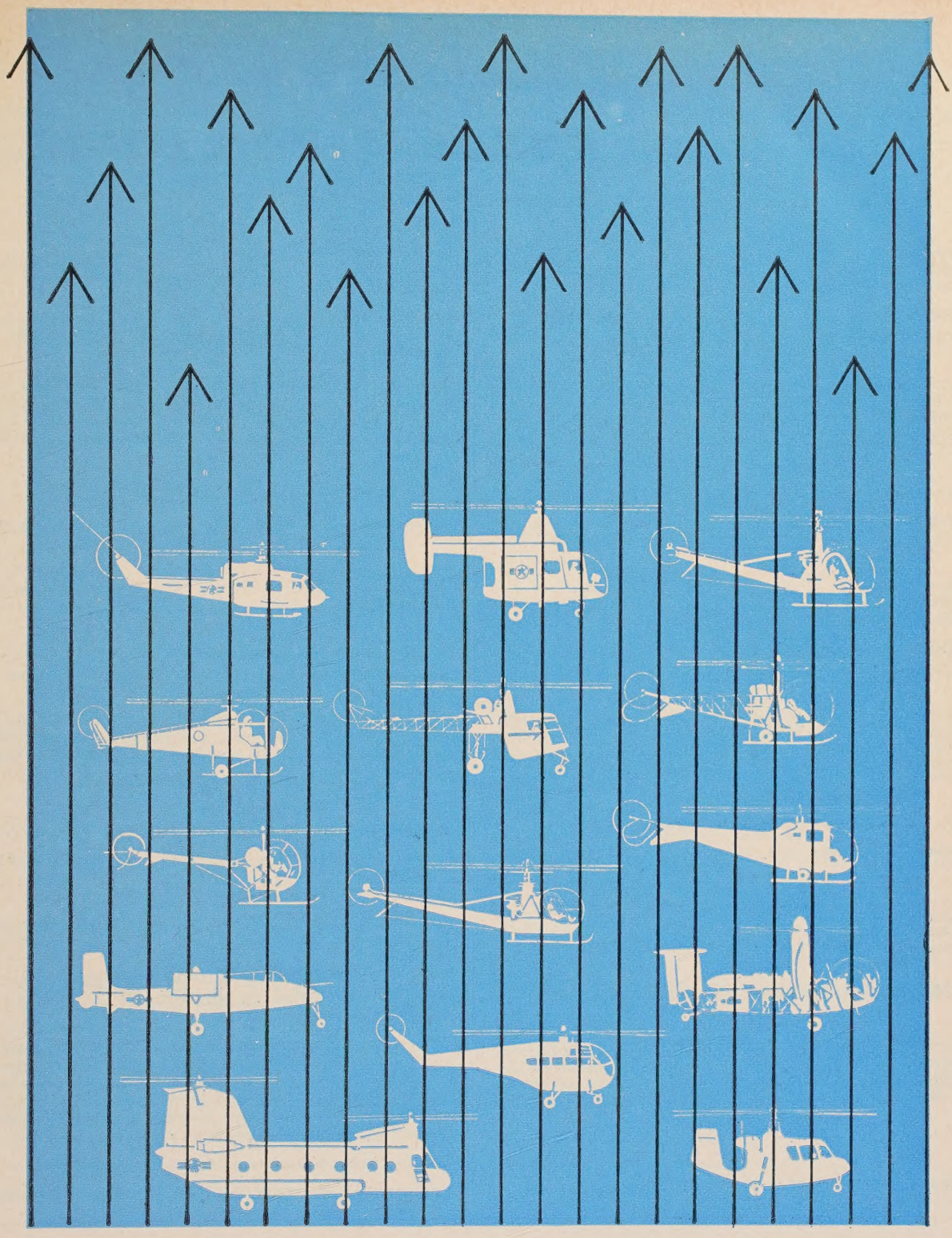

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# in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Special Report:
VTOL, STOL and
Ground Effect Vehicles

Astia code: 1-2, -3
Your code:

## GEM state of the art: the design potential

Review of the design problems and possibilities of ground effect machines as affected primarily by augmentation characteristics. The potential of high-powered low-augmentation designs is considered in detail.

by Victor de Biasi, Associate Editor

space/aeronautics 33/6 (June '60) p. 47

Special Report:
VTOL, STOL and
Ground Effect Vehicles

Astia code: 1-2, -3
Your code:

## V-STOLs: Specifications and performance

Detailed specifications, performance data, and brief development histories on 59 U.S., Canadian, and European developmental or production VTOL and STOL craft. In most cases, configurations are shown pictorially by photo or three-view.

space/aeronautics 33/6 (June '60) p. 62

Special Report:
VTOL, STOL and
Ground Effect Vehicles

Astia code: 1-2, -3
Your code:

## GEM state of the art: the basic configurations

Design analyses of open-plenum and peripheral-jet ground effect machines, GEM-fixed wing hybrids, and ram-wing vehicles. Stability and control problems are treated in detail.

by T. E. Sweeney & W. B. Nixon, Princeton U.

space/aeronautics 33/6 (June '60) p. 50

Aerospace Engineering
Structures

Astia code: 1-3
Your code:

## Honeycomb construction predominates in B-70 structure

Design analysis of use of honeycomb in North American's Mach 3 B-70 bomber. Sketches are given of wing design, joint attachment, and honeycomb bulkhead construction.

by Irwin Stambler, Associate Editor

space/aeronautics 33/6 (June '60) p. 110

Special Report:
VTOL, STOL and
Ground Effect Vehicles

Astia code: 1-2, -3
Your code:

## GEMs: specifications and performance

Detailed specifications, performance data, and brief development histories of seven U.S. and European ground effect machines. Most of the configurations are shown pictorially in photographs and/or three-views.

space/aeronautics 33/6 (June '60) p. 53

Aerospace Engineering
Dynamics, Accessory Systems

Astia code: 12-1
Your code:

## Solving 3-D problems made easy by stereographic projection—II

Shows how to solve three-dimensional problems by stereographic projection. Presents general method of solving spherical triangles for which three consecutive quantities are given, special solutions for triangles with one angle or side equal to 90 deg, and shows step-by-step solution of complex inertial platform problem by graphic analysis, method of successive resolutions, on analog computer.

by Sidney Godet, Reeves Instrument

space/aeronautics 33/6 (June '60) p. 114

Special Report:
VTOL, STOL and
Ground Effect Vehicles

Astia code: 1-2, -3
Your code:

## V-STOLs: State of the art

Discussion of overall trends in V-STOL systems. Advantages and limitations of advanced types now in the experimental stage are reviewed as well as possible future trends in conventional helicopter design.

by Irwin Stambler, Associate Editor

space/aeronautics 33/6 (June '60) p. 56

Aerospace Engineering
Propulsion

Astia code: 27-2
Your code:

## Tyne turboprop designed for low weight, compactness, fuel economy (Design Progress)

Special features of Tyne by which Rolls-Royce has achieved design objectives of low weight, compactness, and fuel economy. Details are shown for compressors and turbines, among other features. Overall engine design is analyzed.

by Randolph Hawthorne, Editor

space/aeronautics 33/6 (June '60) p. 121

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Aerospace Engineering
Systems Engineering, Testing

Astia code: 2-1; 30-4
Your code:

## Astronomical satellite must be designed to extreme accuracies

Review of major problems and present proposed solutions for NASA astronomical satellite design. Also discussed is test setup at Ames Lab. for simulating satellite system operation.

by Irwin Stambler, Associate Editor

space/aeronautics 33/6 (June '60) p. 125

Aerospace Engineering
Accessory Components

Astia code: 1-2
Your code:

## Full-size performance in subminiature rate gyro

Problems in the design of a subminiature rate gyro for low dynamic ranges. Unique suspension gives performance comparable to full-size gyros. "Self-test" capabilities are built in.

by Mike Levitt, Fairchild Controls

space/aeronautics 33/6 (June '60) p. 135

Aerospace Engineering
Materials

Astia code: 17-4; 26-1
Your code:

## Cold-drawing ups nickel's high temperature creep strength

Review of National Bureau of Standards study aimed at obtaining precise data on the high temperature creep of highly pure nickel. One phase of this study showed that cold-drawing significantly increases the metal's creep strength up to about 900 deg F.

by Irwin Stambler, Associate Editor

space/aeronautics 33/6 (June '60) p. 139

Aerospace Electronics

Astia code: 5-2
Your code:

## Transit: Navy claims "world's first operational satellite"

Theory of precise surface navigation by means of the Transit satellite is given, and essential elements of the system are described. Design features of the payload of Transit I-B, first of the Transit vehicles to go into orbit, are covered.

by James Holahan, electronics editor

space/aeronautics 33/6 (June '60) p. 154

Aerospace Electronics

Astia code: 19-4
Your code:

## Aligning inertial platforms at sea

Analytical description of an inertial platform alignment system for shipboard applications. Basic techniques of rough leveling and gyrocompassing are briefly outlined and the design of optimum filters in both rough- and fine-align loops is treated at length.

by Donald C. Martin, Litton Industries

space/aeronautics 33/6 (June '60) p. 158

Aerospace Electronics

Astia code: 8-1
Your code:

## Jetliner's tail cap makes best HF antenna (Design Digest)

Design details of HF and VHF tail cap antennas on DC-8 jetliner. Drawings and photographs explain how antennas were formed as integral parts of vertical stabilizer and rudder. Impedance and power transfer efficiency curves are included.

by Bernard Kovit, associate electronics editor

space/aeronautics 33/6 (June '60) p. 165

Aerospace Electronics

Astia code: 12-2
Your code:

## Firestreak guided by advanced IR homer

Description of the guidance and control system of the British Firestreak air-to-air missile. Novel design features are pointed out, and their advantages and limitations are shown.

by Christopher Dawson, Associate Editor

space/aeronautics 33/6 (June '60) p. 169

Aerospace Electronics

Astia code: 7-2
Your code:

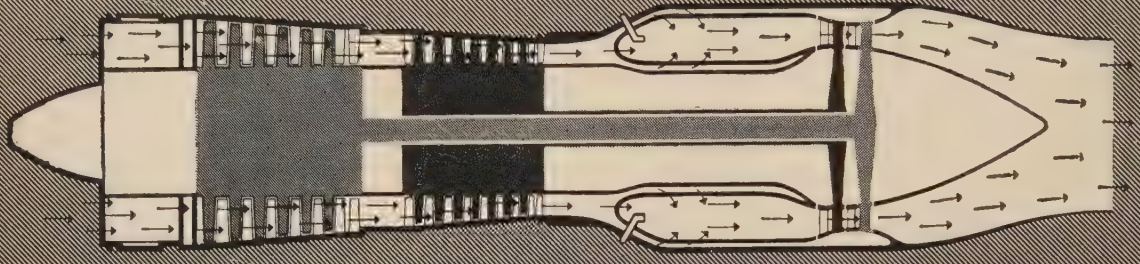
## How to specify and apply pressure and gas-density switches

Basic details and applications of gas-density switches and absolute-air-pressure switches designed to warn of leakage, electric arc-over, and heat dissipation within electromechanical assemblies. Examples of the two basic types of switches are shown.

by Beatrice A. Hicks, Newark Controls

space/aeronautics 33/6 (June '60) p. 181

# Olympus turbojet – high power, low fuel consumption, superb handling qualities, great development potential . . .



## . . . ANOTHER ENGINEERING ADVANCE BY BRISTOL SIDDELEY

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Olympus. The Olympus is one of the most powerful and efficient high-thrust turbojets in service anywhere and therefore most performance details are security restricted. It can be said, however, that the Olympus possesses outstanding handling qualities. In a slam acceleration to full power from ground idling it considerably betters the official requirement. It also has one of the lowest specific fuel consumptions, and the highest thrust/weight ratio of any type-tested aero-engine in its class.

The Olympus owes its excellent all-round performance to the two-spool compressor system, pioneered by Bristol Siddeley and since adopted by the leading aero-engine producers in Britain and the USA. Proof of Olympus reliability is given by the fact that it already has the longest overhaul life of any British fighter or bomber powerplant. And the series has been proved to have enormous development potential. The first production version delivered 11,000-lb thrust dry, while the current engine, the Olympus 21, reaches 20,000-lb thrust dry. Even more advanced Olympus versions are rated at 33,000 lb with reheat.

**Olympus applications**

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## coming next month

**BIG ROCKETS** alone aren't enough for a big missile —just as essential are the little vernier rockets that help control the missile's attitude. Most spacecraft, too, couldn't get along without small rockets in the top stage or even in the payload itself. The special design problems of these rockets will be discussed in detail by Contributing Technical Editor Kurt Stehling.

**STRUCTURAL** and materials details on one of our most ambitious satellite programs will be described in an exclusive design analysis by associate editor Irwin Stambler.

**FOR BOTH** aircraft and submarines, the problem of long range navigation is critical. How far along are we in this field? An answer to this question will be given in a detailed roundup article in the Electronics section.

**NO ONE DOUBTS** that computers can be a tremendous help for the working engineer. But agreement on the computer's usefulness isn't enough— the engineer also has to know just how to use the thing. And about that, he hasn't been told too much in the past. An article in the Electronics section will try to fill this gap by reviewing the basics of actual computer use.

## coming soon

**WHAT ARE** the worst design problems in developing high performance radars? Detailed analyses of the critical points will be given in an extended series of articles in future Electronics sections.

**SOME OF** the most important people in spacecraft design never get anywhere near the hardware—they just work on paper and blackboard to figure out the orbit mechanics of the mission. Yet the results they come up with have a tremendous effect on hardware, since propulsion, guidance, attitude control, etc., all must meet the requirements set by orbit mechanics. A detailed survey will show what is involved in this relationship between theory and practice and how orbit mechanics makes the most of the equipment we can build.

**CLUSTERING,** it's become pretty obvious, is the answer to our need for super-thrust vehicles. It gets us around the tremendous problems of building gigantic single-chamber engines, but of course it also has its own set of troubles. How these are being licked will be outlined in detail by Kurt Stehling.

**CRASH SAFETY** is a goal that aircraft designers can never afford to overlook. A wealth of data on this subject, gathered in an extensive crash study program, will be reviewed, together with the design recommendations that came out of the program.

# S/A editors on the move

OUR EDITORS are on the move as they put the finishing touches to the annual SPACE/AERONAUTICS RESEARCH & DEVELOPMENT HANDBOOK while this issue comes off the press. Those of you on our circulation list who get the HANDBOOK know that it is quite different from all other "annuals".

In the first place, the HANDBOOK deals in technologies, not in vehicle types; nor is it divided up according to military or commercial classification. It is divided into twelve major technical areas for the benefit of those interested in special subjects. Thus, if you want to know the trends in *Dynamics & Structures,* in *Propulsion,* or in *Materials; Electronic Systems* or *Components; Accessories,* and so on, there is a section devoted to each of these technologies.

Each section also has technical articles on the state of the art, written by authorities in their fields exclusively for the HANDBOOK.

The editorial concept of the HANDBOOK follows that of our regular issues: The accent is on the technologies in which our industry is involved, from undersea systems to aerospace.

Not being a "buyer's guide", but containing tables, trends, state of the art, nomographs, and other reference material needed by aerospace technical people, the HANDBOOK has made a reputation for itself unique in the technical publishing field. From what you readers tell us, it is a valued technical reference used the year 'round.

When we published our first R&D issue in June 1953, the world's fastest operational vehicle was North American's F-86D Sabre. Its official speed was 698.505 mph. If speed is the principal measure of performance, then we have come a long way in the last seven years.

One of the technological areas in which aerospace companies are getting more and more involved is undersea systems. In this connection we had a notable visitor last month in Dr. Columbus O'D. Iselin II. Dr. Iselin is one of the foremost oceanographic authorities and director of the Woods Hole (Mass.) Oceanographic Institution. He is preparing an article for the Handbook's new section on Undersea Systems on the thermal structure of the oceans. He came to discuss details of the article with Electronics Associate Editor Bernard Kovit who has been specializing on the side in undersea environments important to guidance, detection, and communications problems in ASW.

Bern has been frequenting such unlikely places—for an electronics specialist—as the Navy's Hydrographic Office and the Biology Branch of the Office of Naval Research. There he has gathered the latest advanced data on the responses of fish and other sea creatures, which add to our understanding of underwater detection and navigation, as well as other biological factors which affect the performance of undersea equipment.

## S/A editor is GSE session moderator

At the IRE's National Aeronautics Electronics Conference in Dayton, Ohio, last month, Victor de Biasi acted as moderator for the Ground Support Equipment session. As we noted in our May issue, Vic was chosen for the role because of his prominence in the GSE field as project leader in special reports on the subject in SPACE/AERONAUTICS.

Meanwhile, S/A contributing editor Kurt R. Stehling, of the National Aeronautics & Space Administration, gave a paper at the 1960 American Rocket Society meeting in Santa Barbara, Calif. His subject was "Design Considerations for Manned Space Stations." Copies of the paper are available from ARS, 500 Fifth Ave., New York 18, N.Y.

**VIC DE BIASI,** S/A associate editor, sums up as GSE session moderator at the IRE's NAECON meeting in Dayton.

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**Publisher**

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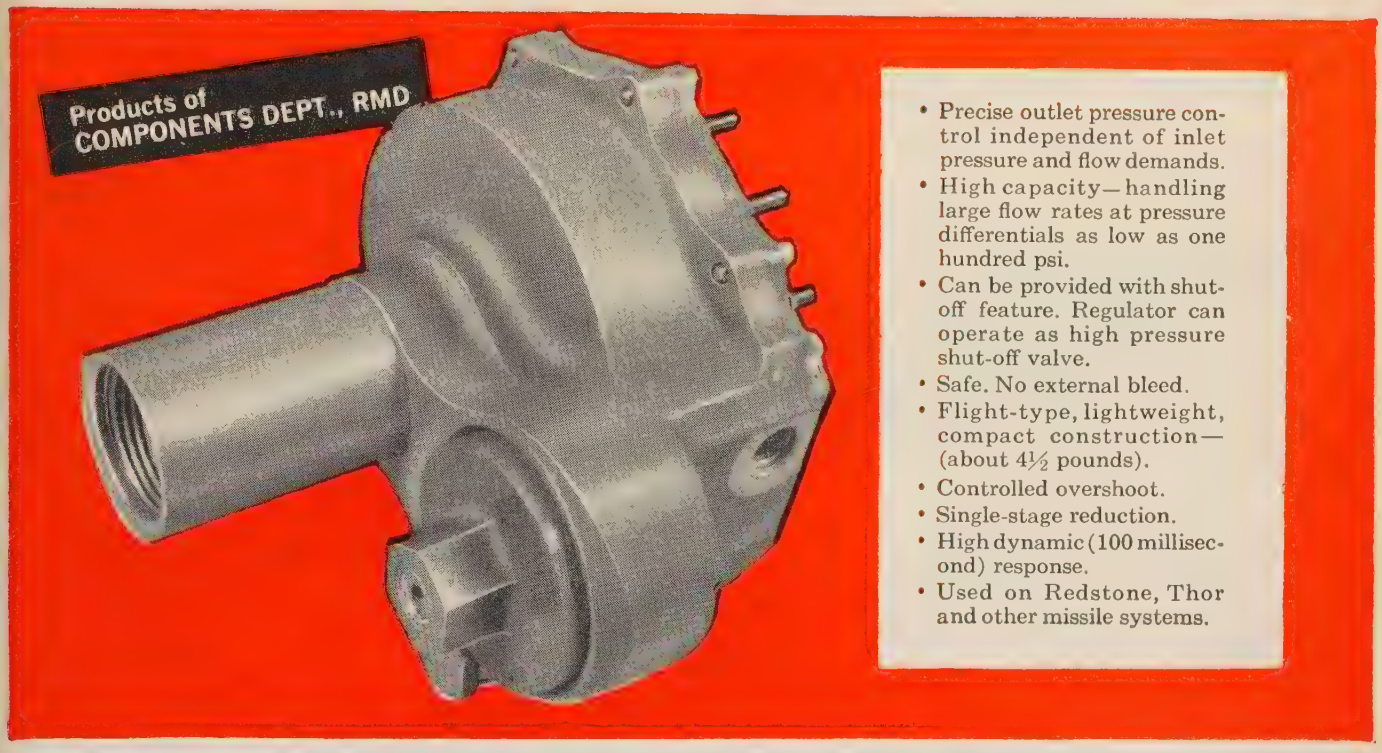


- Precise outlet pressure control independent of inlet pressure and flow demands.
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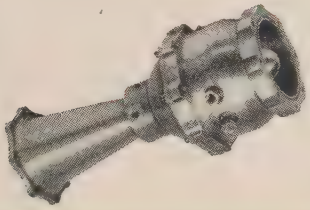

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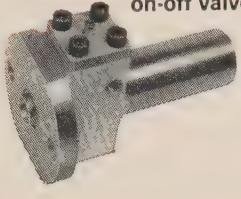

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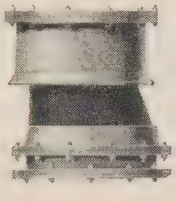

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# On the new J85 Jet Engine: Lightweight, dependable Kidde high-temperature actuators!

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# editorial

## A "cushion" for the future

EVERYONE knows that quite a bit of work goes on in air cushion vehicles, or ground effect machines (GEMs). Not many know how extensive this work is today, however. Our special report (beginning on *page 43*) for the first time puts GEMs into their proper perspective.

Military funding gives the first hint—but only a hint. In fiscal 1960, $1,855,000 was allotted for GEMs: $1,505,000 by the Navy and the Marines, $350,000 by the Army. According to the Office of Naval Research, the estimated total for fiscal 1961 is $7,000,000; for fiscal 1962, up to $10,000,000; for fiscal 1967, $100,000,000.

The Army already has added emergency funding to its fiscal '60 money to the tune of $1.75 million, to be spent in '61. For fiscal '61, the Army plans $300,000; for '62, $1 million. The latter sum covers hardware as well as research.

At least 60 companies are putting money, time, and talent into GEM research, SPACE/AERONAUTICS found. According to ARDC's Wright Air Development Division, GEM spending to date totals about $20 million. Only 25 per cent of this sum was covered by military contracts. Industry, therefore, has picked up the tab so far for about three-quarters of the work in the GEM field.

RIGHT NOW, relatively little money and work is being expended on GEMs. But the prospects for GEMs—both military and commercial—are important for an industry that has been adjusting to small production runs on missiles and advanced aircraft.

GEMs fill in that part of the operational spectrum left blank by copters, VTOLs, and STOLs, not to speak of supersonic and hypersonic vehicles. There is a definite need for GEM capabilities. Some of the military's GEM requirements were spelled out for us by ONR (*see page 49*).

Early doubts about GEMs on the grounds of stability, control, and power are being overcome. And as they are overcome, the potential of GEMs keeps widening. Meanwhile in another field, the . . .

## Helicopter's future brightens

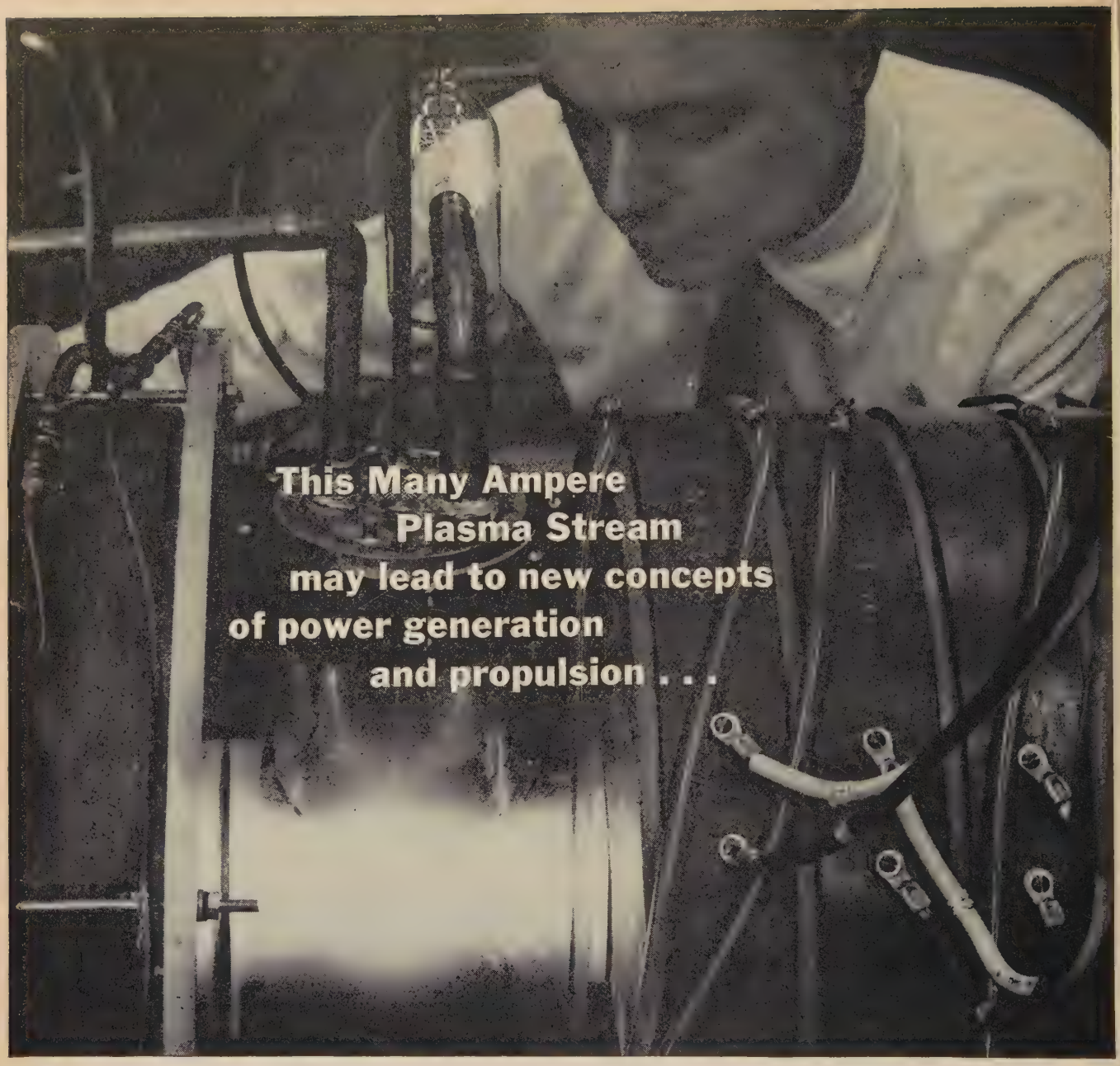
THE U.S. ARMY has just revealed that by 1970 it expects to have about 6000 new copters. Some 3500 will be light observation types, while 2500 or more will be tactical transports carrying 10 soldiers each.

The Army also hopes to add a limited number of flying cranes to its inventory in the 10 years ahead. It already has plans for buying 300 Vertol Chinooks for air mobility in combat zones.

STOLs also will get into the operational picture, if the Army's plans are carried out. Some 250 Grumman Mohawks are foreseen by 1966. The twin-engined AC-1 Caribou, built by de Havilland of Canada, will round out a team composed of a STOL transport and the Chinook copter. Plans call for 300 Caribous.

The shape of the future isn't all spacecraft and missiles. Quite a bit of flying is going to be done in "the nap of the earth"—in greater numbers.

***Randolph Hawthorne, Editor***




A many-ampere source of ions, this device is believed to be the most powerful in operation in any laboratory. Already it is providing new insight into thermonuclear fusion. It may lead to new concepts in propulsion including a method of producing thrust for missions beyond the earth's atmosphere.

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# washington briefing

by A. N. Wecksler and R. M. Loebelson, Washington Bureau Chief & Associate Editor

## A "white paper" with holes

IN THE COMING Presidential campaign, the state of our defenses is certain to be a paramount issue. The Department of Defense has laid the groundwork for the support of its policies and achievements with what has been described as a "white paper."

There is nothing new in the document, but it does represent a culling of all previous policy statements, announcements, and actions of the DOD. As such it will be used by Administration stalwarts to defend their military position against political attack.

The "paper" is in the form of a seven-page letter and the answers to seven questions. The letter was sent to Carter Burgess, of American Machine & Foundry, who was Assistant Secretary of Defense for Manpower, Personnel and Reserve from 1954 to 1957. It was sent by Oliver M. Gale, Jr., special assistant to Secretary of Defense Thomas Gates.

**Heart of the "paper" is that our present superior strength, derived from our bomber force, enables us to limit our production of first-generation ICBMs, while conserving our resources for the more advanced missiles soon to come.**

Conclusion of the "paper" is that "at no time in the foreseeable future will the Soviets be able to launch an attack upon us without receiving in return a blow of unbearable proportion."

Here are the factors on which the DOD position is based:

- First-generation ICBMs may be the best weapon for the Soviets to rely on today, and for the next two years or so—but definitely not for us.

We cannot hide the Atlas as effectively as the Soviets can conceal their missiles. Once they are launched, we would not be able to recall our missiles in the event our warning radar gave us a false alarm.

**Therefore, our main reliance must be on the bomber, which can deliver a greater bomb load than an Atlas with greater accuracy and which can attack several successive targets.**

- Assuming that the bomber for the present is our most effective deterrent, we greatly outmatch the Soviets. We now have over 2000 long range strategic bombers, two wings of tactical bombers, 14 aircraft carriers, 14 wings of tactical fighters that can carry nuclear bombs, Atlas missiles ready for launching from the West Coast, an operational squadron equipped with the Snark, two cruisers and five submarines equipped with Regulus Is, four operational squadrons equipped with Matadors and Maces, and IRBMs in Great Britain.

These all add up to the conclusion, according to the "paper," that there is no deterrent gap.

DOD's position is that we could have produced the Atlas in "any number" we wanted. But we chose to produce a minimum number of first-generation missiles, and press the development of more advanced weapons, like the solid propellant Polaris and Minuteman.

**DOD claims that we are clearly ahead of the Soviets today and that we can stay ahead:**

- We are adding two atomic submarines this year each equipped with 16 operational Polaris missiles, and have a program for adding at least three more subs each year.
- We are adding the supersonic B-58 bomber this year, and have plans for build-up to three wings.
- Atlas force will be expanded to 13 squadrons by 1963. The Titan will be in hard-

*more on page 21*

SILICONE NEWS from Dow Corning

# Semper Flexibilis

## SILASTIC SILICONE RUBBER seals missile sections; withstands -130 to 500 F

Till the moment when it separates during trajectory, the Army Redstone's warhead sits on a flexible seal of Silastic®, the Dow Corning silicone rubber. In fact, all sections of the missile are joined in this manner, to maintain pressure. Chrysler Missile Division engineers also utilize Silastic for many other applications, including ducting, wire bundle clamps and access door seals.

Silastic does these jobs so well because it offers reliability at all times . . . remains flexible even after long storage, at high skin temperatures, under compressive loads, in presence of ozone, cold, moisture. It is unaffected by weathering: 9 years exposure at a South Florida test station has failed to damage sample Silastic parts.

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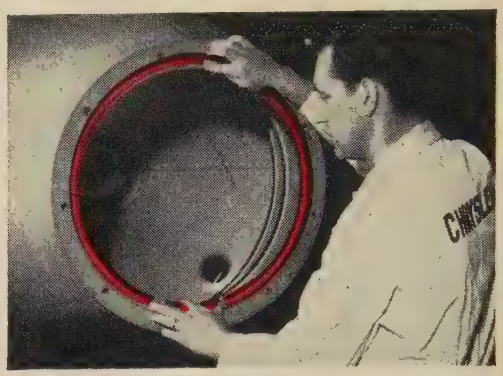
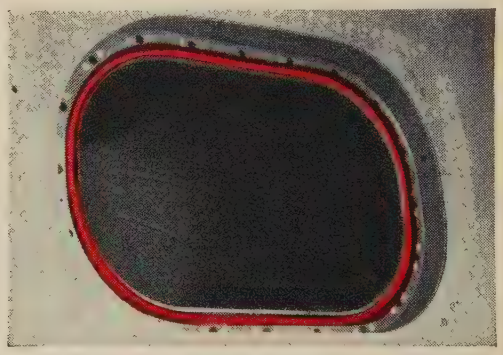
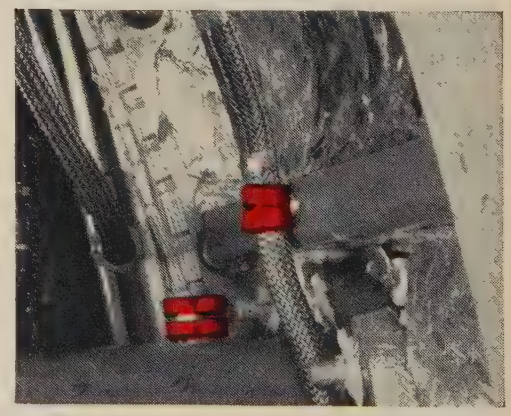


Sealing the nose cone on the Army Redstone is an extrusion of Silastic. Silastic maintains a positive seal despite long periods of storage under load and adverse operating temperatures.



A similar application for Silastic, this time on the Army-developed Jupiter IRBM, another Chrysler-produced missile, is the seal on the angle-of-attack transducer compartment. Silastic was specified because it resists high temperatures encountered in re-entry.



Chrysler Missile Standard Bundle clamps on both Redstone and Jupiter missiles are fabricated of Silastic. Electrical properties of this material are excellent.

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ened bases, next year, and will build up to 14 squadrons after 1963.

- The Minuteman is coming in during 1963.
- The B-52s will be equipped with Hound-Dog air-to-surface missiles.
- All Matadors will be replaced by Maces by 1962.
- The Army will add two surface-to-surface and 3½ surface-to-air missile battalions to our overseas deployment. Seven other battalions will be converted from conventional to missile capability.
- Three modern attack carriers will be added, one with nuclear propulsion.
- BMEWS (the ballistic missile early warning system) will be installed. One station will become operational this year, another next year.

**In the questions and answers appended to the "white paper," DOD claims:**

- We are prepared to handle a limited war.
- The Soviets cannot launch a sneak attack and wipe out our ability to counterattack.
- We don't need a large-scale, continuous airborne alert now.
- The real question is not how we can catch up with the Soviets. It is, "What can the Russians do to catch up with us?"

Gale's "white paper" states that his answers "represent the combined thinking of the Secretary of Defense and his principal scientific and military advisors." But later Gale declared the paper was mailed "before any top officials in the Defense Department . . . knew anything about it."

As things now stand, the Joint Chiefs of Staff are considering a formal protest to Secretary Gates because they believe the white paper skips over several weak spots in the nation's defense posture.

**Among the errors of omission and commission in Gale's document are:**

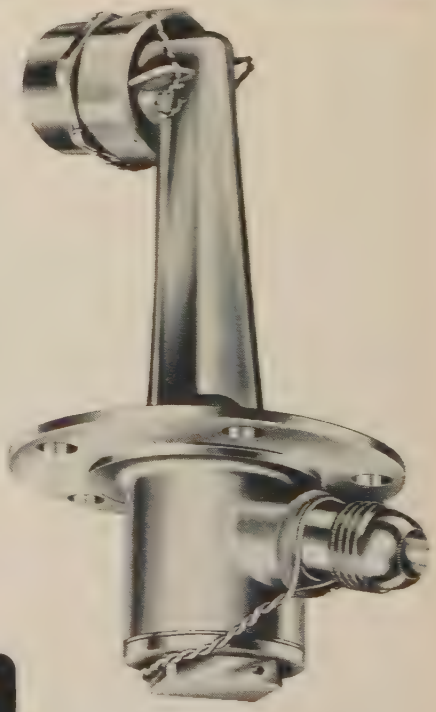
- He talks glowingly about our reliance on manned aircraft and the 2000 long range bombers in SAC. But he ignores the fact that most of SAC's bombers are obsolescent B-47s.
- He contends that the advantage of the Mach 3 B-70 over the Mach 2 B-58 is "distinctly questionable." Yet, as he himself points out, only three wings of B-58s are destined for SAC. He seems to ignore the repeated cutbacks in the B-58 program, as well as the stretchouts in the B-52 and KC-135 program.
- Gale says "operational Atlas squadrons [are] ready for launching from the West Coast." What he doesn't say is that the number of Atlases ready to go is definitely less than 10. He also conveniently forgets to mention that the Atlas site at Vandenberg AFB is unhardened — an open target for Soviet ICBMs.
- "Funds are not a major consideration" in discussions about an airborne alert, Gale claims, for $140 million is provided for fiscal 1960 and $90 million for 1961. However, SAC commander Gen. Thomas S. Power has testified frequently about the additional cash needed for airborne alerts during the crucial period between now and 1963.
- Gale contends that the limited-war capabilities of the services "are adequate to handle any contingency that can reasonably be foreseen." He overlooks the inadequacy of airlift demonstrated in Lebanon and in the recent Big Slam and Puerto Pine maneuvers. MATS commander Lt. Gen. William H. Tunner says his present force is 90 per cent obsolescent "and cannot meet the time limitations established for the airlift of Army forces."
- We could have produced almost as many Atlases as we cared to, but "sound strategic reasoning led us to choose not to produce as many of these first-generation, fixed-site, liquid-fueled missiles as we estimated the Soviets could produce." This is Gale's case, and so he never mentions last year's decision to up the number of Atlas squadrons from nine to 13 and the number of Titan squadrons from 11 to 14. He also ignores the recent Gates edict providing 18 additional missiles for the last six Atlas squadrons.

- **Gale hails the Thor IRBM in Britain as one of our leading deterrent weapons. He obviously chose to ignore the reasoning that prompted the British to abandon the Blue Streak IRBM —that above-ground, fixed-base missiles are sitting ducks for the Soviets' ballistic missiles.**

- He points with pride to the advent of Polaris-firing submarines (two are due this year) and the Minuteman ICBM (beginning in 1963). He fails to mention that neither of these solid propellant missiles has been fully tested. No Polaris has yet been fired from a nuclear sub, and no complete Minuteman has been fired at all.

Gale's "white paper" is noteworthy, for it represents the first full-scale Pentagon attempt to justify current planning. But by leaving so many areas uncovered, Gale may well have provided additional ammunition for critics of the present defense program.

# BENDIX FUEL NOZZLES HELP CONVAIR 880 SET SPEED RECORD



**DELTA AIR LINES'** first Convair 880 airliner recently flew from San Diego to Miami in 3 hours, 31 minutes and 54 seconds, a new record for the southern transcontinental route. On this 665 mph flight, each of the four General Electric J79 engines was fed by 10 Bendix® Fuel Nozzles.

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## Gen. Power pushing for unified strategic command

SAC COMMANDER Gen. Thomas S. Power is again pushing his plan to put all strategic weapons under a unified strategic command. The Navy, seeking to retain control over its Polaris submarines, is likely to fight the Power attempt in DOD conversations and on Capitol Hill.

Power contends the present setup is not as effective as a unified command could be. The unified strategic command, he explains, would be comparable to the theater command in the Pacific and in Alaska. He adds that it would not necessarily be under his or any other USAF general's control. The overall commander might well be an Army general or a Navy admiral, he points out.

Power's ideas were promptly attacked by Rear Adm. L. D. Coates, Jr., the Navy's director of development planning. Coates said only the Navy has the background to command Polaris subs. He added that the Navy would resist a unified command even if there were an unconditional guarantee that the command would be headed by a Navy admiral.

SAC IS PLANNING advanced versions of both Atlas and Titan ICBMs. Atlas is expected to be improved from its present 64,000-nm range (using radio-inertial guidance) to 7000 nm range (with all-inertial guidance). The Titan I, with its 7000-nm range and radio-inertial guidance, will be replaced by the Titan II, with an 8500-nm range and all-inertial guidance. The range increase will be achieved by using bigger second-stage rockets.

SAC's upcoming Minuteman solid-propellant ICBM will have a range of 5500 nm. All three ICBMs will be able to reach 90 per cent of the Sino-Soviet landmass.

## Silo Minuteman to be ready in '62, rail-mounted models to follow a year later

MINUTEMAN is now scheduled to become operational in '62, a year earlier than previously planned. Maj. Gen. O. J. Ritland, commander of USAF's Ballistic Missile Division, revealed that the silo Minuteman will be ready in '62, while rail-mounted models are not due until '63.

Ritland also reported that BMD has no orders from USAF to start the development of an advanced ICBM to replace Atlas, Titan, and Minuteman—even though SAC expects to have such a weapon in its inventory before '70. The current USAF evaluation of the 1,000,000-lb thrust solid rocket booster is not directly tied to such an advanced missile, Ritland said.

USAF IS CONSIDERING an aeroballistic missile flying at 50-100 miles altitude. BMD has not let a development contract for such an ICBM, but several R&D demonstrations and tests have been run off. Such an aeroballistic missile would confuse enemy radars and complicate their long range detection problems.

## Six underground Atlas squadrons will be vulnerable only to direct hits

RITLAND REPORTED that the missiles of the first seven Atlas squadrons will be housed in horizontal bunkers. The next six squadrons will be located underground in steel and concrete silos protected against blast pressures of more than 100 psi, or anything except a direct hit.

The first six Titan squadrons will be set up in a "three-by-three" hardened configuration. The first of these squadrons will become operational at Lowry AFB in the summer of '61.

The Titans subsequent eight squadrons will use storable propellants. They will be emplaced in silos for nearly instantaneous launching.

MINUTEMAN, Ritland reported, "has exceeded our most optimistic expectations." He said the Minuteman concept "forces an enemy to the uneconomical situation of requiring a much greater investment to threaten one of our Minuteman sites than we require to build and maintain it." The first Minuteman is scheduled to start a full flight test program at Cape Canaveral, Fla., late this year.

## Nuclear bomber for late '60s is favored by SAC

SAC STILL FAVORS the development of a nuclear bomber sometime in the late '60s. Gen. Power believes such a vehicle represents the ultimate in mobility—like the Polaris sub, it will be able to roam for long periods. Capable of launching ballistic missiles, Power pointed out, it would provide USAF with a strategic weapon system with an unmatched survival potential.

more on next page

AN AIR ALERT SYSTEM, Power claimed, would cost nothing. He maintained that the spares that would have to be bought to maintain an air alert would be used at a later time if no air alert is put into force.

Power stated that an air alert will be required: when the Soviet Union has ballistic missiles in quantity and the U. S. has no satisfactory missile warning system. He stressed that the Midas and Samos satellites are not expected before '63 and the Ballistic Missile Early Warning System will not become operational in Alaska and England until '61 and '63, respectively.

Power wants one-fourth of SAC's B-52 force on air alert. The original fiscal '61 budget provided for one-eighth of the force for an air alert; the recommendations of the House Appropriations subcommittee provide for one-eighth plus.

## Navy spokesman extols role of manned aircraft for "long, long time to come"

"THE MANNED military aircraft is going to be a vital element in our military forces for a long, long time to come," Vice Adm. Robert B. Pirie, Deputy Chief of Naval Operations-Air, stated recently.

In addition to ordering the Douglas A4D-3, a new version of the A4D Skyhawk that is powered by P&WA J52, the Navy is bolstering its limited-war capabilities with the Grumman A2F-1 and is evaluating entries in the competition for the Missileer fighter, a subsonic aircraft carrying six Bendix-Grumman Eagle missiles.

The Navy is also buying the Mach 2.4 McDonnell F-4H-1 interceptor, but forsees no requirement for a fighter with any significantly higher performance that the F4H Phantom II's. For supersonic attack missions, the North American A3J Vigilante is being acquired in limited numbers.

PIRIE REPORTED that the Navy needs an operating inventory of 7200 aircraft. This means about 1200 planes a year must be bought to take care of attrition, crashes, obsolescence, etc. Pirie declared that money shortages have kept Navy procurement to only half of this number in recent years. As a result, the Navy has been forced to concentrate on buying combat planes at the expense of other programs.

IT WAS "SILLY" of Congress even to think of eliminating the new aircraft carrier proposed in the '61 budget, Pirie said. This statement may have unwanted repercussions. Navy officials are now testifying before the Senate Appropriations Committee and are asserting that the carrier is absolutely vital. Pirie's dig may cause just enough opposition in Congress to rule out any possibility that the carrier will be included in the budget after all.

## Lunar orbits, impacts and soft landings are programed by NASA planners

OUTLINING NASA'S PLANS, Abe Silverstein recently reported that we expect to orbit the moon with an Atlas-Able later this year and next to hit on the moon with the Agena. Still later, a soft landing on the moon with the Centaur and a 2500-lb payload is expected. Another deep-space launching will be attempted with the Agena in '61, and Centaurs will be fired toward Venus and Mars late in '62.

THE TIROS II satellite, due later this year, will measure the heat balance between the earth and the sun. The Nimbus satellite will be used to get a continuous picture of the earth's cloud cover. An improved version of the Tiros, it will be pointed down toward the earth at all times.

AS PART OF NASA'S Echo program, a 100-ft-diameter balloon is to be launched into orbit at 48 deg to the equator this month. The final goal of Echo is a passive communications satellite.

AFTER THE MERCURY system has proved out, NASA hopes to use a vehicle consisting of the Saturn, a new second stage, and the Centaur for a manned moon launching.

## NASA's in-house work may drop from present 20 per cent

SILVERSTEIN SAID NASA is now doing 20 per cent of its work in-house and in contracting 80 per cent. He stated that the in-house percentage may drop as NASA receives more funds in the future.

NASA IS NOT THINKING of launching satellites from manned aircraft like the B-70, Silverstein reported, because its plans call for vehicles too large to be air-launched. DOD, on the other hand, is doing experimental studies on but has

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THOR
MACE
TITAN
HAWK
ATLAS
SNARK
NIKE B
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SPARROW II
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no firm plans for air-launching satellites. Air-launching would make a first stage superfluous; but it also involves a loss in launch accuracy that must still be overcome.

## Army planes to increase from 5500 within 10 years to 8800

ARMY NOW OPERATES 5500 airplanes of 15 types, expects to be flying 8000 aircraft of seven types by '70. This estimate by Lt. Gen. John C. Oakes, the Army's Deputy Chief of Staff-Military Operations, indicates that the Army may soon be buying more planes than either the Air Force or the Navy, though these two services will continue to spend more dollars on aircraft.

The current Army program calls for about 250 Grumman AO-1 Mohawks by '66 for surveillance. As transports a total of 300 de Havilland AC-1 Caribou and another 300 Vertol HC-1B Chinooks will be purchased. The Army also expects to define a requirement for another transport, capable of carrying more than three tons, within the next year.

OTHER REQUIREMENTS involve a light observation copter to replace the present L-19, H-23, and H-13. By '70, 3500 of these copters are to be bought. The Army expects to pick two winners of a design competition for this copter later this year and carry the designs through the prototype stage. Only one of the designs will be placed in production.

There are also plans for 2500 models by '70 of a utility-tactical transport copter to replace the L-20, H-19, H-34, and H-21. In addition the Army expects to procure a limited number of flying cranes in the '60s.

AFTER MONTHS OF DELAY, USAF has given Boeing and Martin the go-ahead on Dyna-Soar. It released $29.7 million in '59 and '60 funds; another $58 million is set aside in the '61 budget.

Boeing, Martin, and other contractors will now begin the design and ground testing work. The first vehicle will be an unpowered glider boosted to near-orbit speed by a modified Titan ICBM at Cape Canaveral, Fla. Later flights, involving a larger booster, will reach orbital speeds. After orbiting the Dyna-Soar glider will re-enter the atmosphere under control of the pilot and make a conventional landing.

Senators Henry M. Jackson and Warren D. Magnuson, both Democrats of Washington, expect spending on the Dyna-Soar program to total $480 million by June '63.

OUTLOOK FOR ADVANCED GSE was described by SPACE/AERONAUTICS associate editor Victor de Biasi at a recent U. of California Seminar on Forecasting and Planning in the Defense Industries. The biggest jumps in missile GSE, de Biasi said, occur when there's a radical change in environment, like the switch to hardened bases. "Hardening the Atlas ICBM weapon system is believed to have increased the GSE prototype cost by 50 per cent," de Biasi declared.

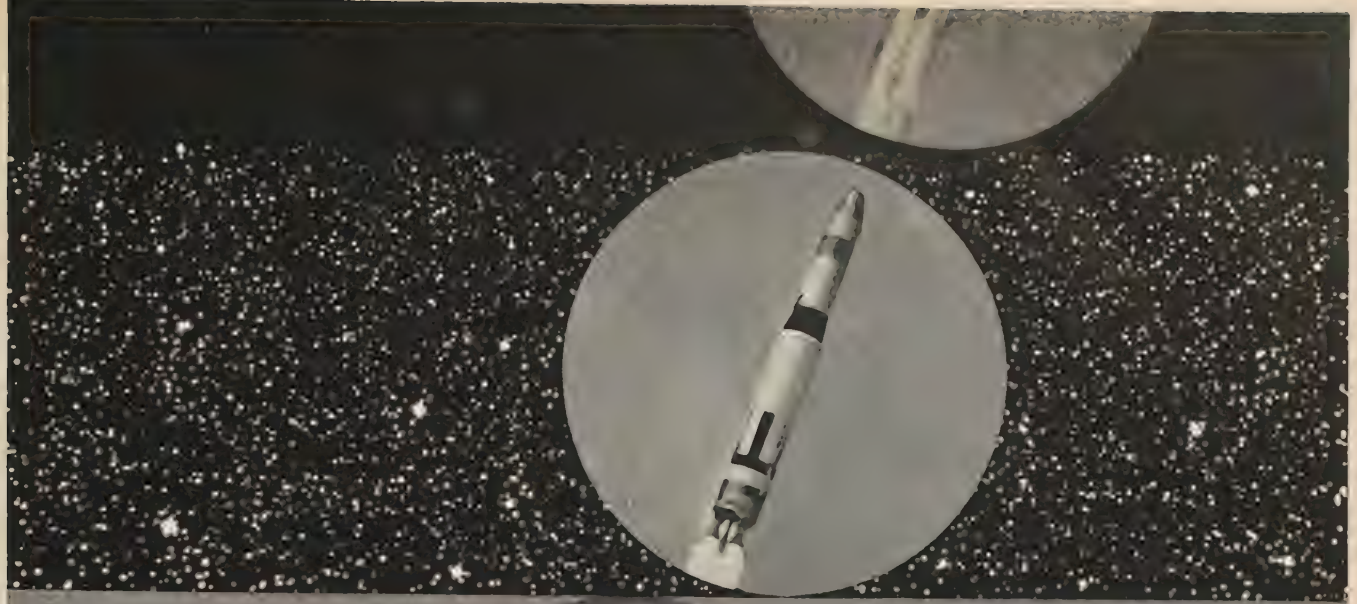
Turning to spacecraft, de Biasi explained that initial GSE costs are running much lower than might be expected. The basic reasons for this development, he pointed out, are that, with our current experimental satellites, there is no need to keep vehicles ready for quick launch but there is wide control of launch conditions and ample time for checking out the subsystems. You can also use ballistic missile GSE for the lower stages with little or no modification. Launching facilities, of course, are basically the same.

"However, as we get to reconnaissance satellites," de Biasi continued, "where the payload design becomes a lot more complex and data processing becomes a major problem, we can expect electronics GSE costs to take another percentage jump upward. Go to the manned skip glide bomber, which will have to re-enter the earth's atmosphere and be recovered, and both mechanical and electronic GSE costs will climb."

## No major changes foreseen as Textron buys Bell

TEXTRON'S ACQUISITION of Bell Aircraft's defense and aircraft business is not expected to result in major management changes. Bell Niagara Frontier, of Buffalo, N. Y., Bell Helicopter, of Fort Worth, Texas, and Hydraulic Research & Manufacturing, of Burbank, Calif., will be reorganized as Bell Aerospace. Bought for more than $30 million in cash, the new corporation will be an autonomous, wholly owned Textron subsidiary.

Chairman Leston P. Faneuf and president Harvey Gaylord will go with Bell Aerospace. The remaining company, Bell Aircraft, will expand and diversify its non-defense activities and have no connection with Textron. It will continue to be controlled by New York's Equity Corp.



# Building Strength Upon Strength... the USAF Ballistic Missile Program

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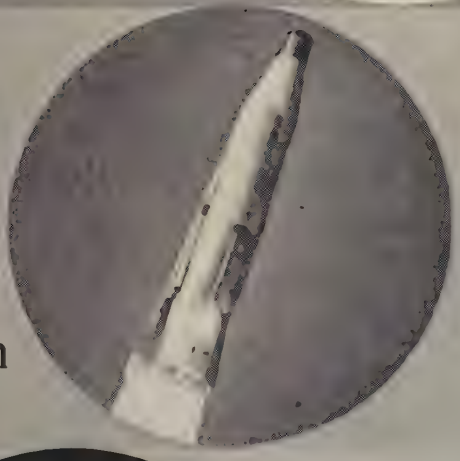

In building strength upon strength in the race for space technology leadership, the knowledge and experience gained from Atlas, Thor, and Titan ballistic missile systems developement is being applied to advance Minuteman. For these programs, under the management of the Air Force Ballistic Missile Division, Space Technology Laboratories has had the direct responsibility for over-all systems engineering and technical direction. As these ballistic missile and related space programs go forward, STL continues to contribute technical leadership and scientific direction.

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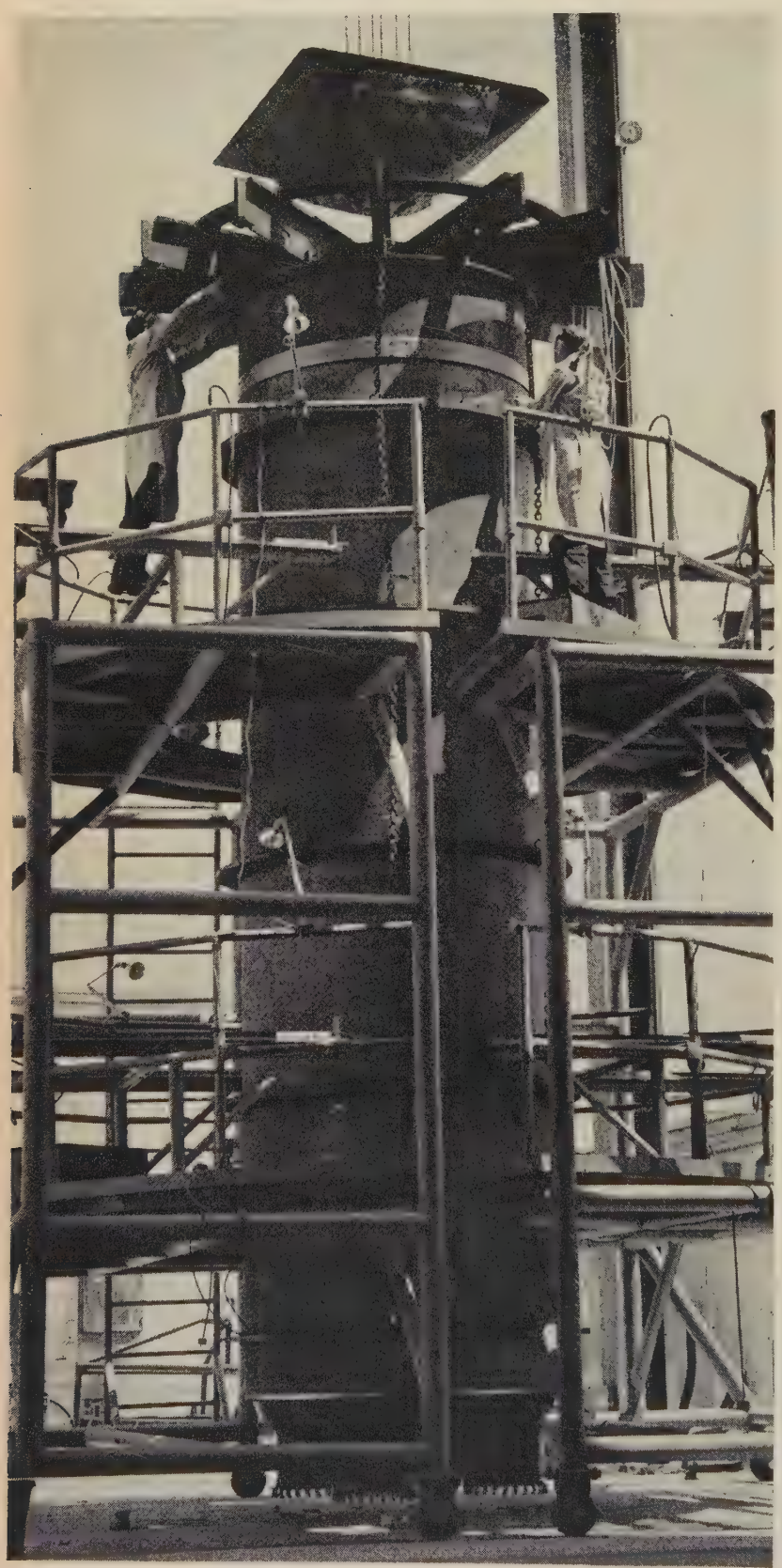

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# industry viewpoint

by **Robert M. Loebelson,** Associate Editor

## Let's educate the public on R&D

IF THE PUBLIC at large is worried about the size of the defense budget, that may be the aerospace industry's own fault, says Leo A. Weiss, chairman and president of Avien, Woodside, N. Y. He is convinced that aerospace firms do not pat themselves on the back enough. What we need, he says, is for the industry and military to start a campaign of public enlightenment.

Weiss believes the public might be less unhappy about defense spending if industry spokesmen and military leaders pointed up the true benefits of military R&D. "Everyone recognizes that military-financed research results in newer and better airplanes, missiles, and space vehicles," he explains. "And if Mr. and Mrs. America take the time to think about it, they subconsciously know that such things as radar and penicillin, which benefit them as private citizens, are attributable to military research funds. But no one has ever made any real attempt to tell the people the full story."

Weiss proposes a four-pronged approach. "In the first place," he says, "there is no doubt that the U.S. should be doing more basic and applied research than it is doing now. We in the aerospace business should lead that fight.

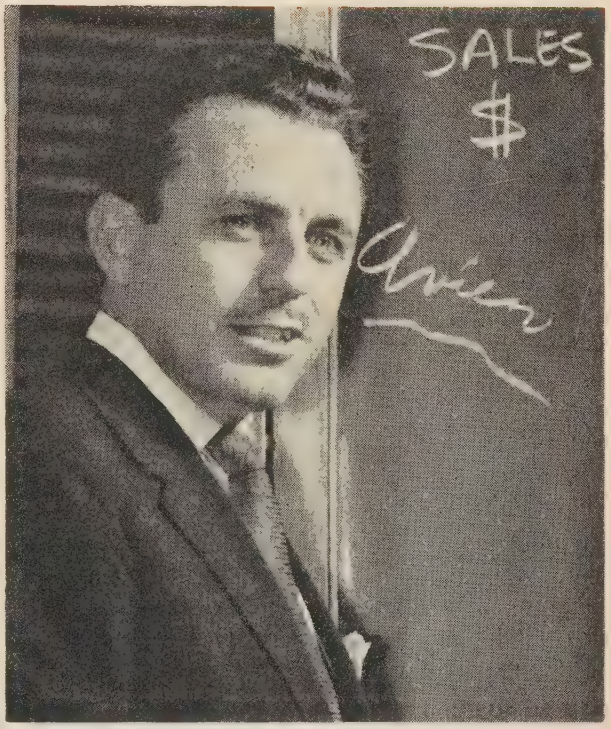
"Secondly, all industry segments associated with the military research program should analyze any past or future civilian 'fallouts' of their studies for the armed forces and publicize these fringe benefits of military research to the greatest extent possible.

"Thirdly, every firm holding an R&D contract from the Defense Department should intensify its efforts to find civilian applications. This is not only very sensible in a straight business sense. It will also enable military leaders to provide better justifications to Congress every year when the military budget comes up for debate.

"Lastly, it makes sense for the U.S. to sponsor a substantial portion of the national research program. These studies tend to benefit the people as a whole, and it is only fitting that the people should finance them."

"The odd thing about research," Weiss points out, "and one important reason why we should really sound off about civilian benefits, is simply that the only periods when R&D was really pushed in this country came when there was some sort of military stimulant—either a war or a threat of war." As Weiss sees it, the public now believes that military R&D is a poor way of advancing man's overall knowledge. "That just isn't true, and we in the industry know it very well. But unfortunately no one is telling the public what is true. We seem to have reached a stage in life where it is fashionable for everyone to fear the government octopus. But more governmental funding of R&D is essential if we are to maintain our competitive military position with the Russians and simultaneously advance knowledge for civilian benefits."

Weiss contends that there are so many commercial areas that have been advanced by military R&D that even some people in the industry don't realize the tie-in.




**LEO A. WEISS**, chairman of the board and president, Avien, Inc.

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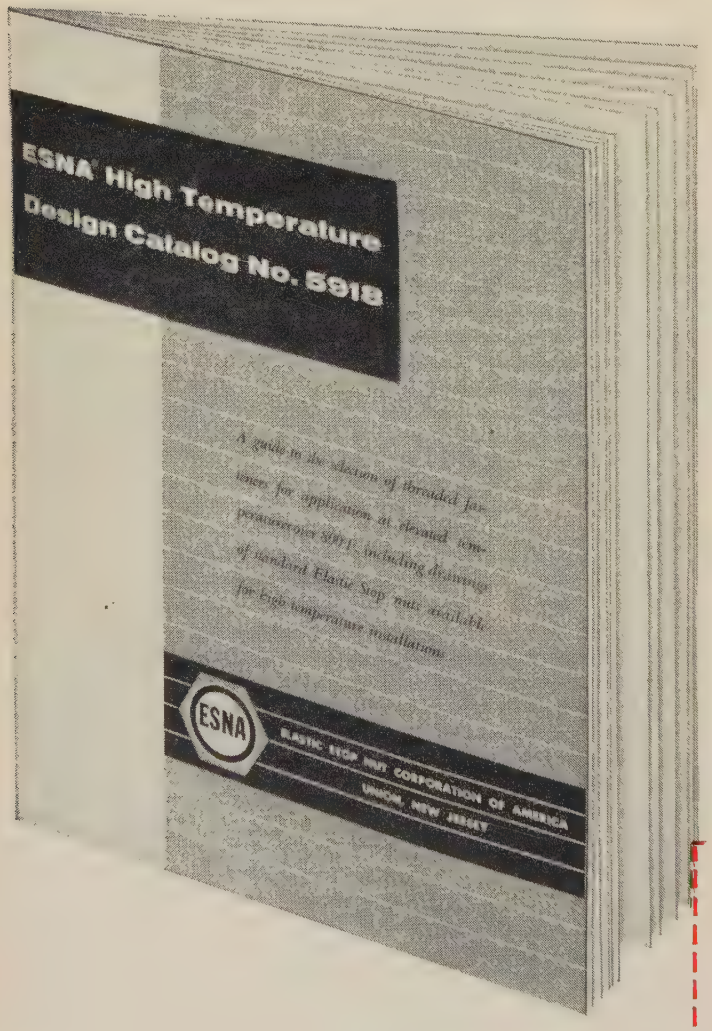


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## Controlled 70 per cent change in rocket thrust

CONTROLLED THRUST variation during an actual firing of a solid propellant rocket was claimed by Rocketdyne's Solid Propulsion Operation group. By mechanical control of the nozzle throat area, a 70 per cent thrust variation was achieved. With a more pressure-sensitivity propellant, company engineers believe, even higher thrust variations can be attained.

•

SPACE MATERIALS was the subject of a recent American Society for Metals Tri-Chapter meeting at Cincinnati. Dr. J. C. Simons, Jr., director of physics research and vacuum technology at National Research, pointed out that one of the greatest difficulties in selecting materials for spacecraft is posed by the radically different environment of space. The effects of the space environment either are non-destructive, or reversible, or cause damage, Simons said.

Phenomena in the first group are the absence of conductive heat transfer, the formation of oxide films, and viscous damping. In the second category are loss of volatile constituents like lubricants and plasticizers, and of surface layers of metals (which leaves super-clean surfaces that cold-weld to each other on contact).

TESTING in what passes for a high vacuum in present research facilities may be misleading, Simons warned. Vacuums of $10^{-9}$ mm Hg or even higher are necessary.

MATERIALS and the re-entry problem were discussed by W. S. Pellini, superintendent of the Naval Research Lab's Metallurgy Division. He gave the energy transfer of a re-entering vehicle's kinetic energy in its passage through the earth's 60-mile deep atmospheric belt as 1500 btu/lb for a vertical return at 6000 mph, 12,000 btu/lb for a circular-orbit satellite at 18,000 mph, and 27,000 btu/lb for a space vehicle re-entering at 25,000 mph.

## Soviet "space ship" with dummy is five months ahead of Project Mercury

FIVE-TON "SPACE SHIP" placed into orbit by the Russians on May 15 beat the first scheduled Project Mercury orbit by at least five months. The Red satellite was described as having a separable pressurized cabin weighing 5500 lb and containing a "dummy space man" and "all the necessary equipment for a future manned flight." The Russians said they are not planning to retrieve the cabin after separation. Instrumentation weight was given as 3250 lb and transmission frequency was 19.995 mc.

National Space surveillance Center at Hanscom AFB, Mass., calculated the satellite's apogee at 226.7 miles, its perigee at 188.5, and its period at 91.25 minutes. Early on May 19, the altitude of the orbit suddenly increased and three new objects were observed trailing the satellite—apparently the cabin had been separated rearward and the ejection rocket had boosted the velocity of the satellite while slowing the cabin. The cabin was thought to have had its apogee reduced to about sixty miles. At this altitude, it could not be expected to stay up very long.

THE SOVIETS' DISCLAIMER of any re-entry attempt started a guessing game among the "usually reliable authorities." It was suggested that the "dummy" might turn out to be a live human being or that at least the cabin was a Dyna-Soar-type glide vehicle that could be guided to a safe landing. If the Russians had told the simple truth, on the other hand, their failure to recover the satellite could mean that they are considerably behind U.S. efforts in re-entry design.

## Float space boosters in ocean, then launch them

A NEW KIND of sea-launch missile system was proposed by the Navy. In a demonstration of Project Hydra at Pt. Mugu, Calif. a dummy missile was floated vertically in the water and then shot into the air by a small solid charge. Lt. Comdr. John E. Draim and Lt. Charles E. Stalzer, designers of the system, suggest that they have hit on a good way to launch space-boosters of Saturn-and-up sizes—no pad and gentry, no cooling problems.

Hydra is not quite operational, however: "X number of years of testing and development must go on before the technique can be applied to any existing weapon system," states Adm. Jack M. Monroe, Pt. Mugu's commander.

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COMMUNICATIONS and movement control for the railway-car-mounted Minuteman missiles will

more on next page

be tested by SAC. The first of six test trains is to leave Hill AFB, Utah, on June 20 and travel over the railroads in that area for about seven days.

Each of the trains will consist of about 14 cars. The railways will furnish motive power and cabooses; the rest of the trains will come from the Army Transportation Corps. The communications center will be a command and control car using single-sidebanc and UHV equipment.

WHEN ADM. ARLEIGH BURKE, Chief of Naval Operations, told the ASW Advisory Committee in Washington, D. C., that there are "no real breakthroughs . . . in sight" for ASW, his crystal ball must have been a little clouded. American Cyanamid has announced that its new AM-9 compound turns water into a jelly-like mass. The company's idea was to find something with which to control seepage in mining and construction, but just think what enough of this stuff would do if dumped into the water around a sub. Or, for passive defense, zones of thick, goo could be set up around harbors, perhaps even all along a coast.

ARMY FIRED a Nike-Zeus from an underground launcher in the first test of a proposed launching facility. There has been no hint before that the operational Zeus might be deployed below ground.

The flight was the fourth success out of six tries at the White Sands (N. M.) Missile Range. With its 450,000-lb thrust booster, the Zeus is the most powerful U. S. missile yet to be fired from an underground launcher.

THE UNDERGROUND LAUNCH system was developed in a series of tests by the Army, Douglas, and Thiokol. Static firings provided data on temperature, pressure, and acoustic effects for the design of the launching cell.

## Large set of wings on Zeus sustainer replaced by two smaller sets

ZEUS' WINGS have been clipped, a public showing of a mockup revealed. Two out-of-phase cruciform sets of small fins have replaced the single, large set on the sustainer of the earlier version.

•

TRITON'S TRIP around the world in 84 days under water undoubtedly will give the human factors engineers concerned with the manning of space stations something to think and talk about. While there are many obvious differences between a sub and a space station, the Triton's exploit confirms again what has already been deduced from the history of the submarine service: you can always find men for hard, uncomfortable, tedious and dangerous service.

But that doesn't mean you can always find them easily. In fact, a Symposium on man in space, sponsored by IAS, NASA, and Rand, one speaker suggested that manning a space station, once the romance has worn off, will be as tough as finding lighthouse keepers. Fred A. Payne, manager of Space Planning for North American Aviation, went on to point out that "the space station crew is going nowhere and will be subjected to a completely static and unchanging environment. The only change which can be anticipated, such as meteor showers, will be detriments."

## Not much advantage seen in more than Mach 2 for trans-Atlantic jet airliners

SUPERSONIC TRANSPORTS were the subject of two recent lectures at the Royal Aeronautical Society in London. M. B. Morgan, chairman of the Society's Supersonic Transport Aircraft Committee, made a good case for an airliner cruising at about Mach 2. He pointed out that there was only a small block-time advantage in any higher speed over trans-Atlantic ranges, while problems and cost of design and construction would increase greatly. Going from Mach 2.2 to Mach 3, he said, would shorten the travel time by only a few minutes, counting climb and letdown, but the direct costs probably would go up by more than a third. In addition, stainless steel construction would probably be necessary for a Mach 3 transport.

FOUR TYPES of power plants for trans-Atlantic service at Mach 2-4.5, were compared by R. R. Jamison and R. J. Lane, of Bristol Siddeley Engines: straight turbojet with turbine entry temperatures of up to 1400 deg K, turbojets reheated up to 1800 deg K, turbo-ramjets, and ducted-fan jets with afterburners. The best engine at Mach 2 is a high-pressure-ratio turbojet, Jamison and Lane said. At Mach 3, there is close competition between the ducted fan and the turbo-ramjet. Its quieter operation, however, might give the ducted fan an edge in both speed ranges, the British designers stated.

Both lectures assumed a conservative takeoff

more on page 34

**a message to men who are not alone in their thinking . . .** Leonardo da Vinci, engineer, scientist, theorist, was the victim of an age when three centuries had to pass before many of his concepts could be regenerated by other men of vision. ☐ Today's quick minds are the fortunate product of an era when methods, materials and machines can be mated to their needs—an age when a spark of inventiveness ignites a fury of progress. ☐ If such a chain reaction of creativity is characteristic of your group, we invite you to discover how Ex-Cell-O can fuse into your operation a reliable source for precision products amply backstopped by research, development and manufacturing facilities, plus the experience required to help you meet the challenge of your own thoughts. ☐ Contact the Ex-Cell-O Representative in your area, or if you wish, call or write direct to our Aircraft Division's central offices, Detroit.

Artist's conception of Leonardo da Vinci's 15th Century spring-driven aerial screw, predecessor of today's helicopter.

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and landing performance, and shorter runways than are feasible for the present big jets. Climb and letdown were figured at less than Mach 1.

## Wrought 5086 especially good for welded missile structures

WELDABILITY STUDIES of wrought 5086 aluminum were reported to the American Welding Society's recent Annual Meeting by M.S. Orysh and I.G. Betz, of Army Ordnance. In ballistic missile design, it was noted, wrought 5086 is particularly good for welding, since its strength in the annealed condition exceeds that of other annealed aluminum alloys.

In tests, 1/16-in. 5086 sheet was welded to 3/16-in.-thick aluminum alloy castings and 3/8-in. 5086 to 3/8-in. castings. In the former case, a single butt joint with a 25-deg bevel on the casting and no root opening was used; in the latter, a 90-deg double-V butt joint with no root opening. Welding was done with an inert-gas-shielded arc and tungsten electrodes.

TESTS SHOWED that cast Almag 35, Al-7Mg, and 214 alloys can be welded to 5086. When the casting was overmatched by the 5086 member so that a failure occurred in the casting, these three alloys had the highest ultimate joint strength (in the order of listing). Casting-filler-metal 5086 alloy combinations that contain both silicon and magnesium as major alloying elements proved less likely to produce joints of reasonable strength and ductility, Orysh and Betz stated, since they formed magnesium silicide.

## Columbium welding is sensitive to contamination

COLUMBIUM WELDING development was discussed by W. N. Platte, of Westinghouse Research Labs. Columbium, he stated, is extremely sensitive to contamination by nitrogen and oxygen. Nitrogen produces the greater increase in hardness and ductile-brittle transition temperature when contamination occurs during welding. Westinghouse therefore did its welding in a closed chamber and used a helium atmosphere—nitrogen can be removed more easily from helium than from argon.

Alloys containing titanium, molybdenum, tungsten, hafnium, zirconium, and uranium were selected as weldable. All except the last were actually tested. Except when titanium and hafnium were used, all weldable alloy additions increased the ductile-brittle transition temperature (in proportion with the amount of alloying). A tungsten alloy was tested in tension at 1000 and 1093 deg C and found to have strengths comparable to the base material's.

NEW ELECTRON BEAM welding unit was described by W. J. Greene, R. R. Banks, and R. M. Niedzielski, of Air Reduction Sales, Murray Hill, N.J. It used a fully developed electron-gun structure with a double-focusing system designed to make it easier to join reactive metals, like molybdenum, tungsten, and beryllium.

A 16-in. oil diffusion pump, backed up by a six-inch booster pump, and a mechanical pump that can pump 11,000 cfm at 0.1 micron pressure are used. Almost every type of joint that can be welded with arc methods has also been made on the new machine in thicknesses from 0.005 to 0.2 in, it was stated.

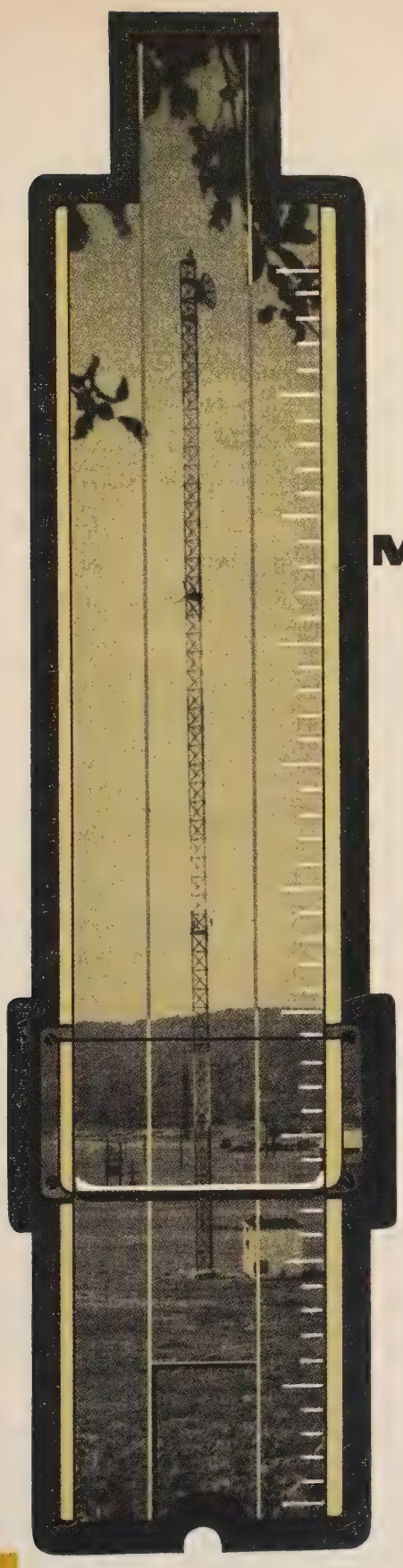
## Nuclear rocket seen as first acceptable space engine

HIGH-THRUST NUCLEAR engine was urged by M. W. Hunter, assistant chief engineer of space systems at Douglas, before the recent Aviation/-Space Writers Association meeting. "The nuclear rocket engine," he said, "may become the first truly acceptable space engine [for] exploration of our solar system . . . Any nation which acquires this capability first will move into a space leadership which far overshadows any space achievements to date."

The need for convenient trip scheduling Hunter claimed, rules out very-low thrust propulsion systems like ion rockets and solar sails. The most obvious way to use nuclear energy, he said, "is . . . a reactor [that is] mounted in a rocket chamber and heats a working fluid, preferably hydrogen, to form a high speed jet . . ."

WITH HYDROGEN, the problem is that the nuclear reactor must be hotter than the exhaust gas if heat is to be transferred to the exhaust. However, the performance of hydrogen at the melting point of high temperature materials like graphite, Hunter said, is about twice as much as that of a high energy chemical like hydrogen-oxygen. "Doubled performance is always worth investigating," the Douglas designer pointed out, "as is the possibility of using better materials than

more on page 36



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graphite and . . . other improvements, such as high-expansion-ratio nozzles."

MINUTEMAN TEST SILOS at Edwards AFB, Calif., were thrown open to the press recently. The eighth launch of a developmental silo Minuteman came off concurrently completing a series that originally called for 18 shots, USAF'S Ballistic Missile Division revealed.

This series included full-scale silo launchings with curtailed propulsion duration. In addition, full-scale test runs of each of the Minuteman's three solid rocket engines have been successfully completed as well as rocket sled tests of prototype guidance systems. BMD stated that progress to date indicates that the Minuteman will become operational in '62.

DESIGNERS OF ADVANCED transports must cooperate closely with airport authorities and government's regulatory agencies, Francis T. Fox, general manager of Los Angeles' Dept. of Airports, emphasized in a recent speech. Fox said he wanted to point out that it's simply a "fact that the Mach 3 transport must be acceptable and usable at the . . . jet age airports of today.

"Investments by the Federal government in navigation, air traffic control, and communication facilities, as well as those by communities and airport operators in airport facilities, are so enormous that development of the air vehicle can no longer be planned without taking this factor into account . . . It's time that aircraft be designed to fit the airport system and not vice versa."

## 300-lb instrument capsule to be developed for moon landing

PAYLOAD PACKAGE for a lunar impact will be developed by Aeronutronic, NASA stated. The 300-lb instrument capsule will ride piggy-back on a larger spacecraft (under design at Jet Propulsion Lab) to within 20-25 miles of the moon's surface. It will then be detached and a retro-rocket will slow down to an impact at less than 300 mph. Its instruments will include a seismometer, and temperature recording devices. A crushable honeycomb structure will be used.

The spacecraft and the capsule together will weigh 800 lb. An Atlas-Agena B will be used as the booster. Flight is scheduled for somewhere within the next two years.

•

DOUGLAS' S-4 SECOND STAGE for the Saturn will use a cluster of four Centaur-class engines developing a total of about 80,000 lb thrust. It will be mounted on the eight-engine, 1,500,000-lb thrust first stage; the third stage will be modified Centaur with two engines powered by liquid oxygen and hydrogen.

Saturn will be able to boost a 25,000-lb payload into an earth orbit or send a 12,000-lb space-probe around the moon. Douglas plans to build the S-4, which will be 50 ft high and 18 ft in diameter, at its Santa Monica, Calif., plant. The Centaur-class engines will be built by Pratt & Whitney Aircraft.

## Completely obscured targets can be hit by new A2F-1

NAVY'S NEW low-level attack bomber, the Grumman A2F-1 Intruder, is the first plane that can accurately deliver nuclear or conventional weapons on targets completely obscured by weather or darkness. To bring off this feat, it uses a "digital integrated attack navigation (DIAN) system."

The Intruder has hydraulically actuated tilting tailpipes. Dropped into the tilt position, the pipes direct the jet exhaust downward for additional lift and short-takeoff capabilities. The plane uses two P&WA J52-P-6 jet engines, each delivering 8500 lb thrust. A subsonic, swept-wing design, it carries a pilot and a radar operator.

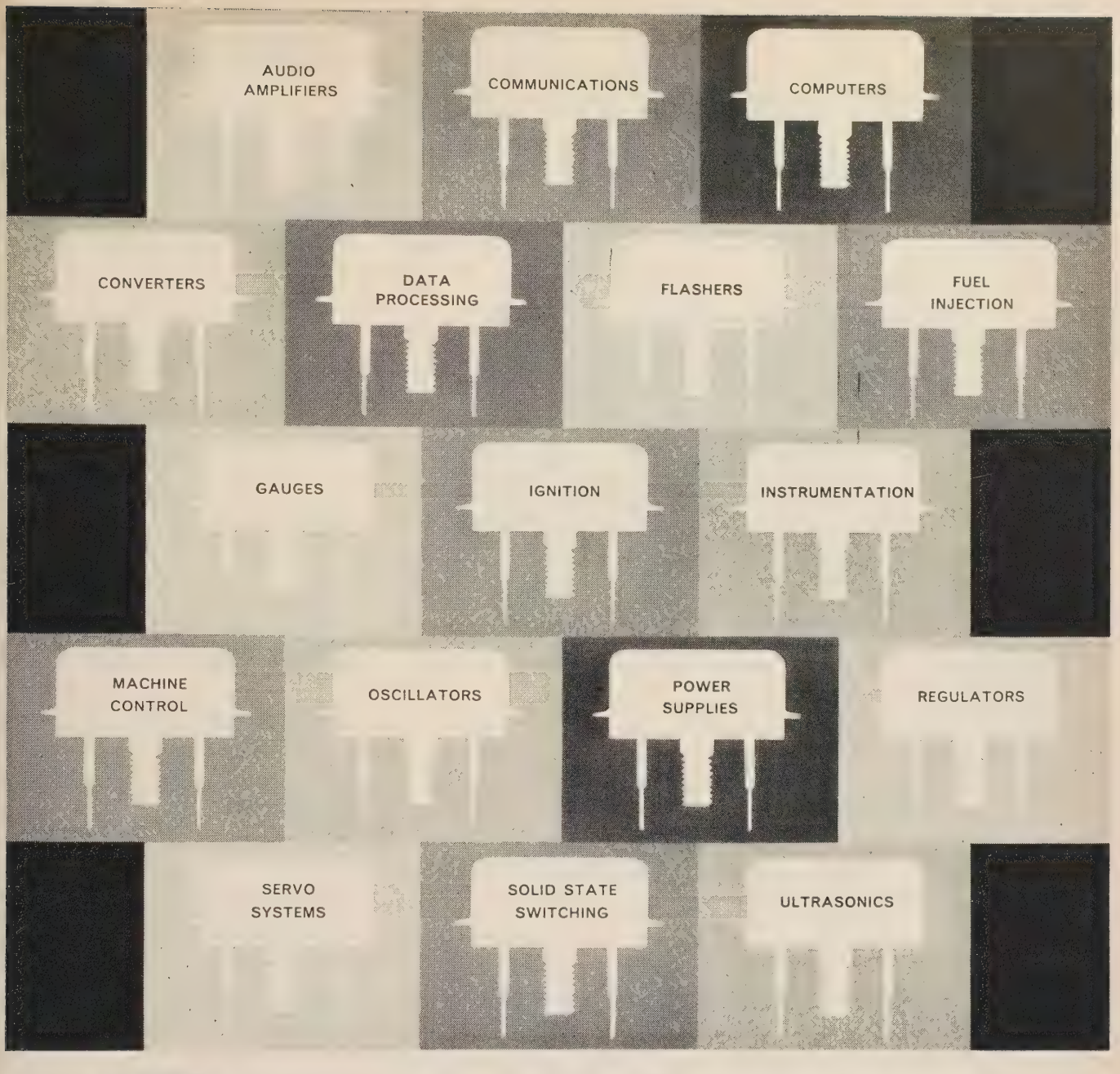
•

NEW SUPER FALCON air-to-air missiles designed by Hughes are the radar-guided GAR-3A and the infrared-guided GAR-4A. The latter, says Hughes, has a new infrared detector that surpasses all earlier detectors in spotting smaller targets at greater range.

Both missiles use a new Thiokol-Hughes solid propellant engine that produces high thrust for launch and then a lower thrust for sustained flight. They can be launched at Mach 2 from Convair F-106As. They are about seven feet long, 6½ in. in diameter, and weigh 145 lb.

ARC-JET space engine produced about ¾ lb thrust continuously for 47 hours in a test at Avco's Advanced Research & Development Division. The experimental rocket gets its thrust from the expansion of a working fluid (helium or hydrogen) that is heated to a very high temperature by an electric arc. In the test run, helium was the working fluid and arc power consumption was 30 kw. A specific impulse of 1000 seconds was achieved.

The small arc-jet rocket weighs only 3.5 lb. It consists of chamber, nozzle, power supply, and working-fluid storage.



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*Engineering notes from the* **SM/I REPORTER**

BY STANLEY M. INGERSOLL, *Capabilities Engineer*

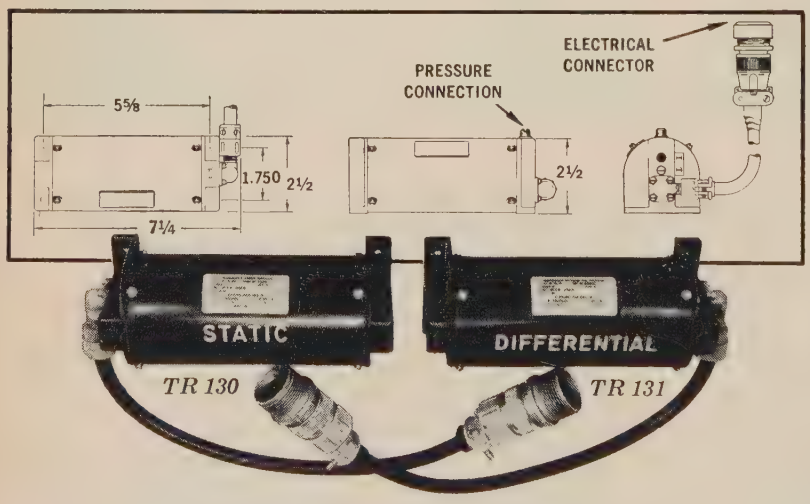
## Report No. 6
## TR 130 Absolute Pressure Transducer and TR 131 Differential Pressure Transducer

These SM/I pressure transducers are precision built 400-cycle instruments using a cruciform cross-section helically twisted Bourdon tube with an electromagnetic pick-off to generate an electrical signal proportional to absolute pressure (TR 130) or differential pressure (TR 131) for use by computers and precision instrumentation. The design completely eliminates any mechanical friction or stiction and reduces hysteresis to an absolute minimum. The relation between output voltage and input pressure is linear.

They are particularly well adapted for use in aircraft because of high accuracy, low threshold, rugged, compact design and inherent repeatability of performance. The units have a mean time to failure of over 5,000 hours logged in in-flight operations. They meet the requirements of military specification MIL-E-5400.

## Typical Performance Specifications

| | |
|---|---|
| Scale Factor | 0.0001487 volt/volt/mm Hg. |
| Applied pres. range | 0 to 787 mm Hg. (absolute) |
| Damping (Restoration time) | 0.1 second from full scale deflection to zero scale |
| Ambient temp. range | −65°F. to +175°F. (continuous duty) |
| Acceleration | Will withstand 30g without damage |
| Output voltage | 0 volt to 3.50 volts for 30 volts of 400 cycles power applied and at load impedance of 20,000 ± 2% ohms |
| Frequency range | 380 to 420 cps |
| Size | 2½"x 2½"x 7¼" |

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# calendar

**June 5-9**—Meeting & Aviation Conf., American Society of Mechanical Engineers, Statler Hilton Hotel, Dallas, Tex.

**June 13-15** — Powder Metallurgy Conf., Metal Powder Industries Federation & Powder Metallurgy Committee, The Metallurgical Society, American Institute of Mining, Metallurgical and Petroleum Engineers, Hotel Biltmore, N. Y. C.

**June 15-17**—Heat Transfer Fluid Mechanics Institute, Stanford U., Stanford, Calif.

**June 20-23**—Avionics Panel, Radio Wave Absorption, Advisory Group for Aeronautical Research & Development of the North Atlantic Treaty Organization, Athens, Greece.

**June 20-July 30**—Berkeley Symposium on Mathematical Statistics & Probability, AFOSR/Mathematical Sciences Directorate, U. of Cal., National Science Foundation, Office of Naval Research, and Office of Ordnance Research, invitation only, U. of Calif., Berkeley, Calif.

**June 22-24**—Conf. on Standards & Electronic Measurements, Institute of Radio Engineers' Professional Group on Instrumentation; Radio Standards Lab, National Bureau of Standards; American Institute of Electrical Engineers' Instrumentation Division, NBS Boulder Labs, Boulder, Colo.

**June 23-25**—16th Annual Meeting, Institute of Navigation, USAF Academy, Colorado Springs, Colo.

**June 26-July 1**—Meeting & Apparatus Exhibit, American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City, N. J.

**June 27-June 30**—Conf. on Coherence Properties of Electromagnetic Radiation, AFOSR/Physical Sciences Directorate, Optical Society of America & Rochester U., invitation only, Rochester, N.Y.

**June 27-29**—Convention on Military Electronics, IRE, Sheraton-Park, Hotel, Washington, D. C.

**June 28-July 1**—National Summer Meeting, Institute of the Aeronautical Sciences, Ambassador Hotel, Los Angeles, Calif.

**July 18-19**—Liquid Rockets & Propellants Conf., American Rocket Society, Ohio Union Building, Ohio State University, Columbus, Ohio.

**July 28-29**—Seventh Annual Symposium on Computers and Data Processing. Denver Research Institute, U. of Denver, Stanley Hotel, Estes Park, Colo.

**August 1-3** — Fourth Global Communications Symposium, IRE, U.S. Army Signal Corps.. Statler Hilton Hotel, Washington, D. C.

**August 8-11** — Western National Meeting, American Astronautical Society, Olympic Hotel, Seattle, Wash.

**August 8-12**—Pacific General Meeting, American Institute of Electrical Engineers, El Cortez Hotel, San Diego, Calif.

**August 15-20**—11th Annual Congress, International Astronautical Federation, Royal Institute of Technology, Stockholm.

**August 23-26** — Western Electronic Show & Convention, IRE, Ambassador Hotel, Los Angeles, Calif.

**Sept. 5-11**—Farnborough Flying Display & Exhibition, Society of British Aircraft Constructors, Farnborough, Eng.

**Sept. 12-16**—16th Annual General Meeting, IATA, Copenhagen, Denmark.

**Sept. 12-16**—Second International Congress, International Council of the Aeronautical Sciences, Zurich, Switzerland.

**Sept. 21-25**—National Convention & Aerospace Panorama, AF Assn., Civic Auditorium & Brooks Hall, San Francisco, Calif.

**Sept. 27-30**—Power Systems Conf., ARS, USAF, U.S. Army, U.S. Navy, National Aeronautics & Space Administration, Atomic Energy Commission, Miramar Hotel, Santa Monica, Calif.

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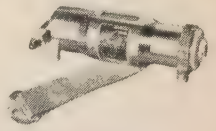

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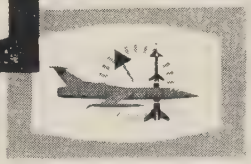

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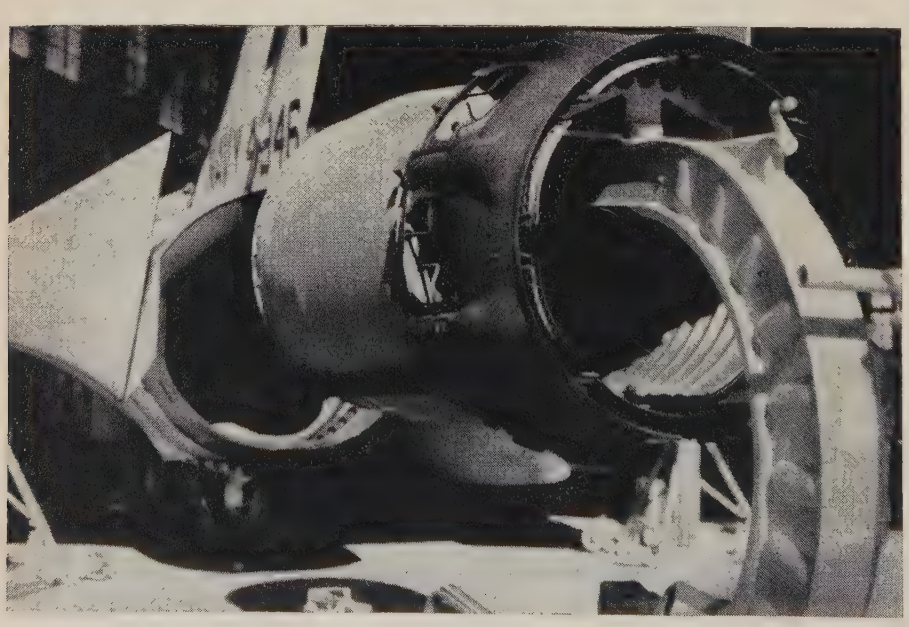

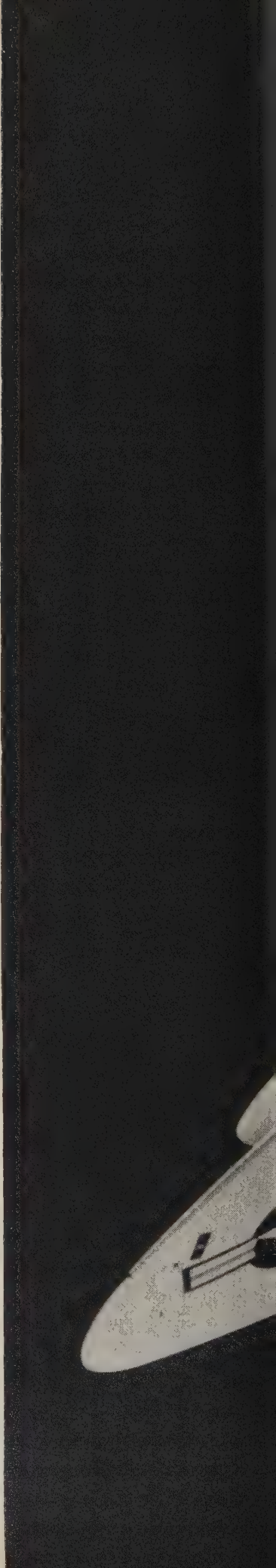

USS United States Steel

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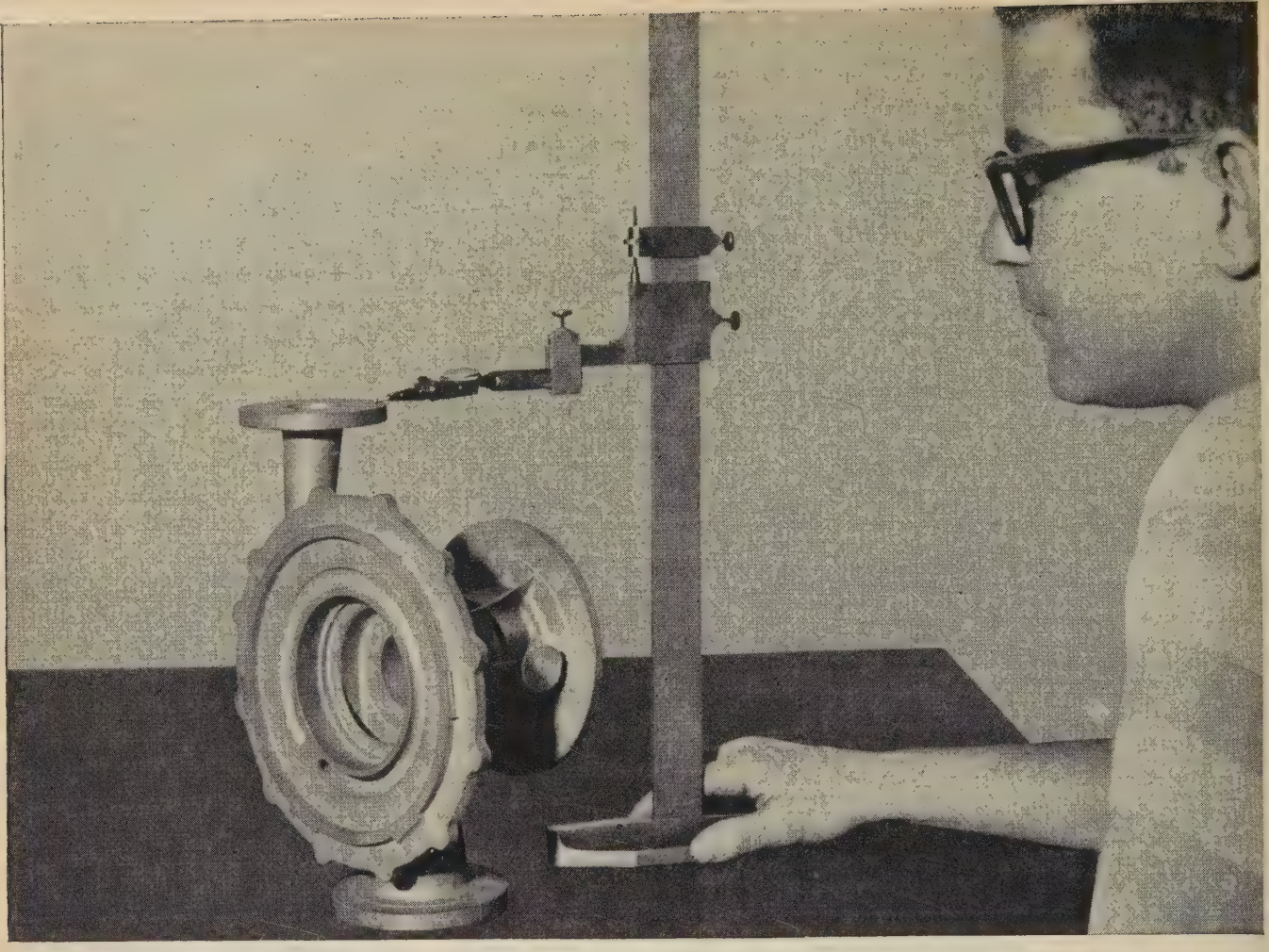

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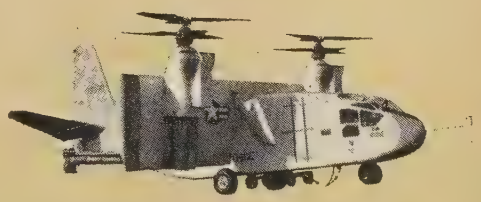
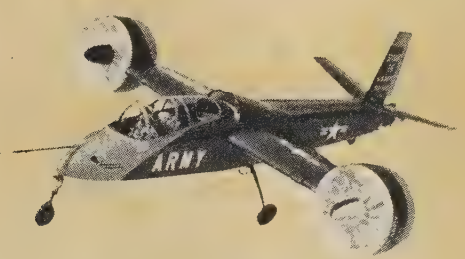
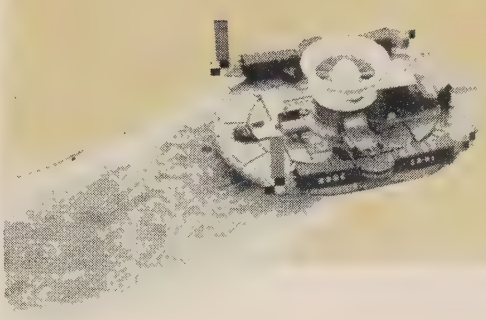
*A Space/Aeronautics special report on the outlook for "unconventional" aircraft from the familiar copter to the futuristic flying saucer.*



# V-STOLs and GEMs:

## obvious potential, limited sales



THE ODDEST THING about the entire odd breed of "unconventional" aircraft is that these vehicles have been with us for a decade and a half—and yet haven't accounted for any substantial slice of the aerospace industry's sales. Whether it's helicopters, vertical and short take off and landing (V-STOL) aircraft, or ground effect machines (GEMs), it's always the same story—obvious potential, limited sales.

The total military and commercial sales of the six major copter manufacturers, for example, have come to about $300 million a year for the past several years now. No sharp increase is expected.

For V-STOL, the military has spent about $142.5 million in the last 10 years—the Army close to $40 million on flying test beds and another $34 million on two STOL aircraft (the de Havilland Caribou and Grumman Mohawk); the Navy about $37 million; and USAF $25 million on VTOL test beds and $6.5 on a Navy-USAF fighter-bomber.

GEMs are so new that next to nothing (by military procurement standards) has been spent on them to date. In the current fiscal year, the Office of Naval Research (ONR) is putting up $780,000 (including $500,000 from the Marine Corps); BuShips, $375,000; BuWeps, $350,000; and the Army, $350,000. Next year, however,

*more on next page*

**by Robert M. Loebelson and Christopher Dawson**
Associate Editors

**In the U.S.**

- Military and commercial copter sales will continue at a level of $300-400 million a year unless V-STOL spending climbs.
- No sharp rise in spending on V-STOLs is likely unless the Pentagon decides these vehicles are ready for production.
- There'll be a substantial demand for GEMs if all current tests prove satisfactory and if the services stay convinced that the powerplants required for GEMs would not be more useful in conventional or VTOL aircraft.

**In Europe**

- European countries largely will build their own copters, partly under license from the U.S.
- Better STOL designs will be pushed at the expense of true VTOLs.
- Any appreciable demand for GEMs is unlikely until these craft have proved their usefulness.

spending on GEMs is expected to total $8.75 million. It will further increase, according to current ONR estimates, to perhaps as much as $10 million in fiscal 1962 and then to $100 million by fiscal 1967.

In terms of future potential, the helicopters appear most controversial. Firms like Bell, Hiller, Sikorsky and Vertol are certain the market for their product will continue to grow, especially with the advent of shaft turbines. But many observers in the aerospace industry believe the copter's potential is limited. Copters don't fly forward fast enough, they argue, and cost too much to operate.

## Copters said to be uneconomical

Harold H. Dice, General Motors vice-president and general manager at Allison, is one of those who are convinced copters are economically unsound. He says, "We've discovered it takes 13 hours of service to provide one hour of helicopter flight. The servicing costs are much higher than for fixed wing planes. The answer seems to be turbine-powered VTOLs. These will require no more servicing than other aircraft."

The Federal Aviation Agency obviously also believes that V-STOLs will be an important part of aviation's future—its Project Hummingbird is studying the effects V-STOLs will have on air traffic problems.

To date, most of the research effort on V-STOLs has been financed by the Army, though USAF and the Navy have also been active. About $20 million was jointly spent by the Army and USAF on two convertiplane test beds, the McDonnell XV-1 and Bell XV-3. On its own, the Air Force has been studying jet VTOL with the Ryan X-13, Bell X-14, Hiller X-18 and is financing studies by Canada's Avro Aircraft on a high-performance jet VTOL fighter bomber to succeed the Republic F-105. It is also monitoring the Army-financed Avro VZ-O, a saucer-like aerial jeep powered by three Continental J69s.

## AF looking for three more VTOLs

According to Nicholas Erkeneff, VTOL specialist at ARDC's Wright Air Development Division, USAF expects it will need at least three VTOL vehicles besides the Mach 2+ fighter bomber Avro is studying: an assault transport, a cargo transport for large missiles, and a rescue aircraft.

The Navy's interest in VTOL goes back to the Ryan Vertijet (long before it became the USAF X-13) and the ONR-sponsored Collins Radio Aerodyne. More recently, the Navy and USAF collaborated on a fighter bomber mockup (occasionally referred to as the Bell XF-109), but this project has been dropped.

The Army has been trying out various approaches to the V-STOL problem. Among the vehicles it now has under test are: Vertol's VZ-2 (tilt wing), Ryan's VZ-3RY (vectored slipstream). Doak's VZ-4DA (tilting ducts), Fairchild's VZ-5FA (vectored slipstream), Chrysler's VZ-6, Aerophysic's VZ-7AP, and Piasecki's VZ-8P (all three ducted-fan aerial jeeps), and Avro-Canada's VZ-9 ducted-fan flying saucer.

Several other approaches are under study, some of them privately funded. They include Vanguard's fan-in-wing project, under test at NASA-Ames for USAF, a USAF-sponsored GE-Ryan fan-in-wing proposal, the Lockheed C-130 in a boundary layer control (BLC) version, Lanier's BLC Paraplane, and Helio's slotted-flap Helioplane.

Erkeneff believes each of the military services now foresees a need for special VTOLs. He predicts that the total military requirement for VTOLs will amount to at least $250 million a year before 1965.

## VTOL purchases expected after '70

GE's Flight Propulsion Laboratory Department—which is developing a propulsion system to enable VTOLs to fly forward at jet speeds—expects some commercial VTOL purchases by the early 1970s. However, it isn't ready to go out on a limb. Says GE:

"No airline is willing to put its dollars into immediate financing of still-to-be-proved VTOL concepts. The military, however, has urgent need for the tactical advantages that VTOL has to offer. If they are sold on VTOL, then they will put up the money to research and develop it. This will eventually lead to commercial applications."

At Allison, large sums have been spent on studies of V-STOL designs for commercial service. The company's V-STOL specialist, Dan H. Jacobson, says their studies show that V-STOLs will eventually overtake conven-

tional aircraft—there'll be more of them, and more will be spent on them. Other conclusions drawn by Allison are:

- For relatively short range planes of the size of a Convair, separate lightweight lift engines appear ideal.
- For longer range aircraft of the size of the Electra, tilting-wing or pods look good. The potential for this type may amount to well over 500 planes.
- For 2-4-place vehicles flying at 75-100 mph and covering ranges of 150-200 miles, a combination of two 250-hp shaft turbines similar to the Allison 250 and a fixed rotor looks good. Such vehicles could be designed as military aerial jeeps or as private aircraft.

Less speculative are two conclusions widely shared by V-STOL experts:

- The feasibility of VTOLs has been proved beyond question. What is lacking now is top-level Pentagon decision to go ahead with buying VTOLs.
- VTOLs look more promising than STOLs. They are not much harder to design than STOLs (if at all), and they have many advantages over STOLs.

## More V-STOL research not needed

Not surprisingly, there's hardly anyone in the V-STOL field who believes that further research to prove the principle of vertical lift would do much good. For example, Maj. Joseph Wosser, the Marine Corps' V-STOL expert, points out that ONR is now spending nine times as much on GEMs as on V-STOL. In former years, ONR, (which had been funding 20-30 per cent of all U. S. vertical-lift studies) paid out as much as $1 million annually on V-STOLs. Now it has cut back to $250,000 a year, pending a Pentagon decision to go ahead with the V-STOL program. As Wosser puts it, "We feel there is no point in trying to resolve every technical problem until we know whether the program will continue."

The effort on GEMs, on the other hand, is building up. The Marine Corps is running tests at Quantico, Va., on the GEM-1 (built by National Research Associates and Pegasus) and GEM-2 (a labyrinth-seal type built by Switzerland's Carl Weiland). GEM-3, powered by two Solar T62s and built by National Research, is under construction and should be ready for testing before the end of the year.

## $20 million a year on GEM studies

Erkeneff estimates that the total spending on GEMs now has reached about $20 million a year, only $5 million of which is backed by military contracts. The other $15 million have been invested by various private companies ranging in size from Spacetronics, a small Bethesda, Md., firm, all the way up to Allis-Chalmers, Allison, Curtiss-Wright, Ford, etc.

As the military sees it, there are three major questions about the feasibility of GEMs:

- Can a GEM survive in the open sea? It can—the Saunders-Roe Hovercraft SR-N1 last summer crossed the English Channel dealing with four-foot swells while skimming 10 in. over the water surface.
- Can a GEM get up enough speed? It can—a Weiland design powered by two Lycoming engines with a combined output of 500 hp last February achieved 50 mph on Lake Zurich, while traveling eight inches over the water.
- Can a GEM carry a useful load? This question will soon be answered in tests of the GEM-3 and other vehicles with loads of 2000 lb and more.

In Europe as in the U. S., the ordinary copter is the only V-STOL available today in production form. The potential of less conventional V-STOLs and of GEMs is not yet well enough proved for people to know just what these designs can do for them.

*more on next page*

**in this special report . . .**

. . . a team of SPACE/AERONAUTICS editors reports on the "low end" of the aerospace flight spectrum. V-STOLs and ground effect machines may not have all the glamor that surrounds missiles and spacecraft, the vehicles at the high end of the spectrum, but there can be no doubt about their steadily increasing importance in both civil and military aviation.

The importance of GEMs especially is growing by leaps and bounds—in the U.S. alone, some 60 companies are working on air cushion designs (quite a few of them in hope of getting the jump on their competitors). The military services are closely following these design efforts—for many of their requirements, operational GEMs would be just the ticket.

This SPACE/AERONAUTICS report is pretty well a worldwide effort: The information on V-STOLs and GEMs uncovered in this country by a team consisting of associate editors Irwin Stambler, Vic de Biasi, and Bob Loebelson is backed up by Chris Dawson's coverage of European developments. Chris' contributions are included in this article as well as in the two state-of-the-art features. The Editor was project leader on this special report.

A limited number of reprints of our special report is available to meet orders for up to 25 copies. For bulk orders, special rates will be quoted. In either case, please write on organization letterhead to Reprint Dept., SPACE/AERONAUTICS, 205 E. 42nd St., New York 17, N.Y. Orders probably will be filled in September.

SPACE/AERONAUTICS' special report on V-STOLs and GEMs begins with this article. The other features of the report are:

GEMs: State of the Art ..... 47
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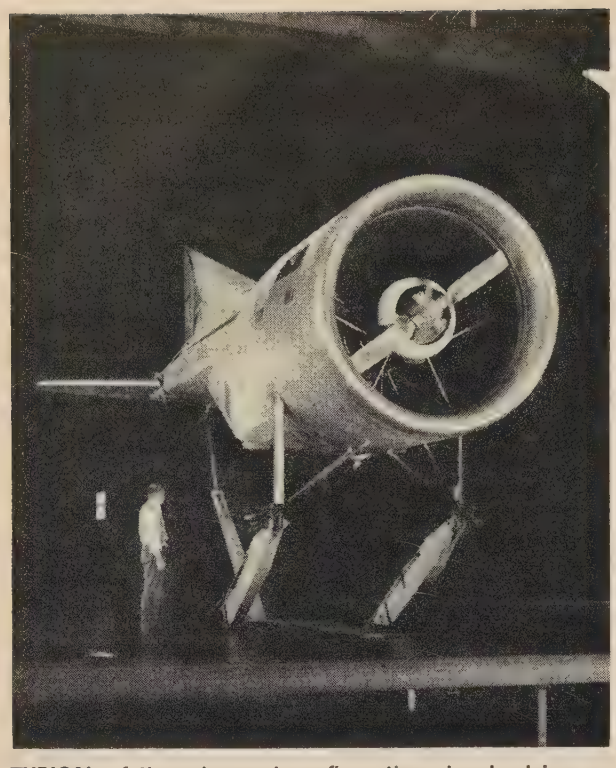
Randolph Hawthorne

EDITOR



**TYPICAL** of the advanced configurations involved in current V-STOL research is the Collins Aerodyne, shown here in a wind tunnel at NASA Ames.

Military requirements in Europe for future copters center around large transports that can also be used as cranes. (Pure cranes are considered uneconomical.) The British army is particularly interested in carrying bulky loads in a VTOL, and has been looking at the Rotodyne. The Westland Westminster transport copter will probably be ordered by RAF, and may be adapted to meet the Army requirement.

## Europeans to build own copters

Substantial numbers of copters of all sizes will be required by both civil and military operators in Europe in the next few years. Countries capable of building their own copters will do so, either to their own design or under license. Any license production is most likely to rely on U. S. designs. Most European companies that have developed successful copters to date have made fairly heavy use of experience gained from license production of U. S. models (particularly Sikorsky's). This trend will continue in the larger sizes, but among the small copters entirely native designs will probably predominate, especially in Britain and France.

European firms working in the V-STOL field are mainly interested in developing executive transports, liaison planes, and feeder air liners. For use in Europe, these types must be able to use minimal ground facilities—usually primitive runways or grass fields. Most existing or projected V-STOL machines fall just short of clearing 50 ft in a distance of 500 ft, and most work for the future is aimed at upping the size and cruise performance of aircraft able to use existing facilities, rather than further reducing the runway requirements.

A number of smaller European firms are trying to meet STOL requirements by refining the aerodynamics of basically conventional air planes. The limit of this sort of development has probably already been reached. Few civil operators will accept the higher running costs implied by the drastic increase in power loading that would be needed to go any further. To them the copter then becomes more attractive.

## Direct lift for a VTOL jetliner?

The direct-jet-lift machine at present is of interest only to the military. There has been much speculation in Britain about using direct lift for a supersonic VTOL airliner, the assumption being that, without direct lift, such a plane's take off performance would be worse than that of the current jetliners. This assumption seems unlikely to prove valid, and the practical problems of VTOL airliners of course would be immense.

Direct-lift VTOL is being developed—mainly for fighters—in Britain, France, and West Germany. The military requirements are still uncertain, and there are two schools of thought among the manufacturers. One foresees a strike fighter with perhaps transonic performance and designed for ground attack and tank busting, particularly in a limited war. Such a design is what the RAF has in mind right now and is hoping to get in the Hawker P-1127.

## Common NATO design for VTOL plane

The second school of thought holds that a high performance plane with very rapid climb is needed as an interceptor (which may or may not be manned). This plane would carry air-to-air weapons against manned bombers, and missiles. European countries think no U. S. aircraft meets the requirements of this mission and are therefore going ahead with various designs of their own. In the end, a common NATO design will probably be agreed on.

Two British organizations are working on GEMs, a type in which the military in Europe hasn't shown much interest so far. The better-known project is the Hovercraft, developed by a company specially set up by National Research Development. The company's first design, SRN-1, has been built and thoroughly tested by Saunders-Roe. A second Hovercraft is under development. It is being designed mainly for over-water flight.

The Swiss engineer Carl Weiland has also done work on GEMs, again mainly for over-water applications. His designs, which have been taken up in the U. S., are the only important ones that rely on the labyrinth-seal method. With this technique, part of the air leaking out from the air cushion under the GEM is drawn in by a prop and returned to the cushion. This process is repeated by a number of stages in series until an acceptable pressure drop is achieved.

As no one in Europe has as yet formulated any requirement for GEMs to meet, there is little evidence today of any market potential. It is up to the GEM designers to show where their machines could be used to advantage. The only visible market so far seems to be remote plantations in undeveloped country—that's what Britten-Norman the other British firm doing GEM work, is designing a Hovercraft-like vehicle for.—End

# GEMs:

## state of the art

Key to success may lie in radical approaches that are unconventional even in the unconventional GEM field

## The design potential

**by Victor de Biasi,** Associate Editor*

AT LEAST 60 companies in the U.S. are feeding time, money, and talent into ground effect machine (GEM) research. Most of them would prefer to remain unnamed, since they are quite convinced that they are stealing a march on their competitors. Some firms probably are actually getting ahead of the field. But even they will have a nasty surprise when they find out exactly who else is also working on GEMs.

A solid measure of ignorance generally is characteristic of the GEM field. Published reports and interviews with industry and government experts make it quite clear that we have merely scratched the surface in the development of GEMs. As might be expected under the circumstances, experiment has run ahead of theory, which so far fails to explain many phenomena observed in testing. For one thing, we still have not settled on the best aerodynamic approach to the "air suspension" of vehicles.

We do know, though, that there appears to be a spectrum of GEMs and therefore of practical and theoretical problems. You can put GEMs—which are all vehicles riding on a "bubble of air" of slightly more than atmospheric pressure that lets them "skim" over land or water—in three categories, according to mission:

- *High-Augmentation Vehicles*—bulk-transport craft operating at ratios of height off the ground to vehicle diameter ($H/D$) of 0.1 or less;
- *Low-Augmentation Vehicles* — general-support craft operating over an $H/D$ range of 0.2-0.8 (or to the fringe of free-air operation);
- *Full-Range-Augmentation Vehicles*—V-STOL craft operating mainly in free flight outside the air cushion and above $H/D$ values of 0.8, but using the air cushion for landing.

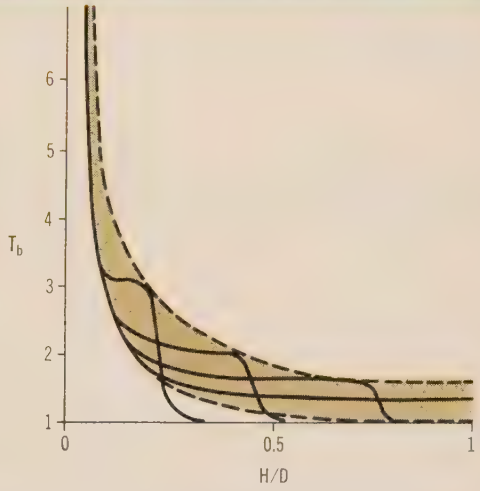



**FIGURE 1:** General air cushion augmentation characteristics of peripheral-jet designs as given by theory (dashed curves) and experiments (solid curves).

* Parts of this article are based on contributions from a GEM designer who has requested that his name be withheld.

*more on next page*

## U. S. Military GEM Requirements

- **Amphibious support vehicle** to replace LCVPs, DUKWs, etc. Would have 60-knot cruising speed and 80-knot top speed, carry a five-ton payload, and require a 1-2-man crew. Power for lift and thrust from a single source could be varied to generate excess thrust (for speed) or excess lift (for clearing obstacles).

- **Sub hunter-killer vehicle** to spend most of their life floating on water, but able to lift off and scoot toward the target at 60-80 knots. Would operate about three feet above the waves and be armed with underwater missiles and depth charges. Both manned and unmanned versions are needed (See S/A, Jan. 60, "New Systems Concepts Developing for Undersea Weapons," p. 43.)

- **Utility barge or cargo lighter vehicles** to carry 10-ton payloads at 60-knots while operating 1½ ft over the water. Operation would be restricted to the favorable environment of relatively calm lakes and rivers and flat terrain.

- **Recon vehicle** to carry a one-ton payload at 100 knots while operating at maximum hovering distances off the ground. Would have a one-man crew and automatic height and speed control system, be lightly armored, and be armed with small missiles.

- **Ocean transport vehicle** to carry 500-ton minimum payloads. Will probably require a gas-cooled reactor for endurance.

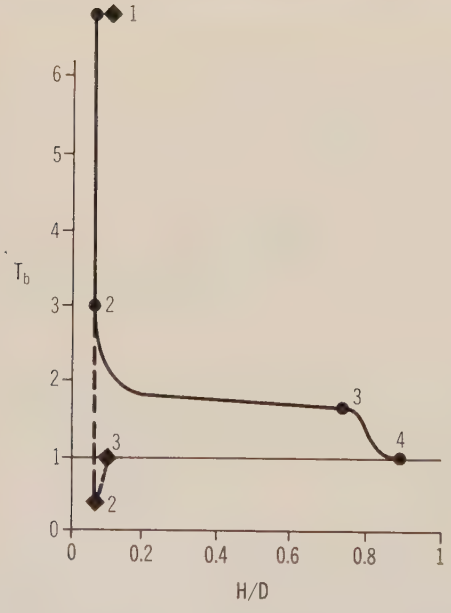



**FIGURE 2:** Comparative characteristics of air-cushion designs (circles) and air-bearing designs (triangles).

There is no reason common basic powerplants, structures, and integrated control systems could not be developed for all three families of vehicles, since power and size are the only points of difference. We might even be able to get away with a single structure for experimental work across the whole spectrum. By merely installing powerplant of different sizes, we would use this structure to check out operation in the ground cushion, on the cushion's fringes, and in free space. Once we're past the development stage, a series of standardized vehicles would then be produced with interchangeable subsystems.

Most of the work reported to date has been on high-augmentation vehicles. There is growing interest though, in some of the higher-powered low-augmentation craft, and even in free-flying ones.

### Immediate uses for some transports

There are immediate applications for transport-type designs that might operate at $H/D$ values as low as 0.01-0.03. Most U.S. and British GEM designers are concentrating their efforts in this area. Eventually, though, engineers expect to get up to around 0.1 $H/D$. In England, Hovercraft Development is working on a commercial successor to its SRN-1, a design that was built by Saunders-Roe and that crossed the Channel last July. In the SRN-1, air cushion pressure is both created and maintained by two roughly concentric annular curtain jets around the periphery of the vehicle. For a given cushion pressure and height, the power requirement is proportional to the circumference—i.e., the length of the jet—while the lifted weight is proportional to the surface area. This design favors a large vehicle and is considered economically competitive in the form of a 400-ton cross-Channel ferry. With 90-knot cruise speed, this ferry would be faster than a ship and possibly cheaper.

The worst remaining problems are the spray cloud at low speeds, the dust cloud over land, and control at low speeds and in high speed turns. Little is known of Hovercraft's new design other than that the horizontal thrust will be increased over the SR-N1's and that the proportions of air flow going to the curtain jets and to the propulsion units will be variable.

Experimental results show that there is a critical ratio of jet exhaust distance off the ground to jet curtain thickness at which a hovering vehicle becomes unstable. Apparently, when this ratio approaches unity, the vehicle tends to become dynamically unstable in pitch and roll. The SR-N1 avoids this danger by using its double-jet curtain to more or less seal in the air cushion.

Another vehicle similar to the SR-N1 is being built by Britten-Norman at Bembridge, Isle of Wight. This company, which specialized in equipment for aerial crop spraying, sees both transport and spraying applications for GEMs on remote plantations in undeveloped country. Their GEM is backed by a fruit-importing firm that will test the machine on a notoriously inaccessible banana plantation in the Cameroons.

The Britten-Norman Cushioncraft is smaller than the SR-N1 and is said to have a slightly better power-weight ratio. Fifteen tons has been mentioned as a possible payload.

On some pioneering designs, the sticky problems of stability and control have been solved for high-augmentation designs. The job now is to reduce the amount of dust and spray the cushion kicks up and to cut down internal and external aerodynamic losses. Another im-

portant goal is to minimize the power needed to maintain pressure on the air curtain. Except for sealing in the air cushion, this power does no useful work.

For the time being, horizontal speeds seem limited to 80-100 knots. The 100-knot figure apparently is a key reference in most of the theoretical and experimental work to date.

For vehicles operating in a horizontal or at a slightly positive angle of attack, there begins an aerodynamic shift of the center of pressure that is pretty much independent of the vehicle shape. Normally, the pressure bubble acts at the 50 per cent point of the "chord," or base, of the vehicle. But when aerodynamic lift takes over, the center of pressure shifts to the 30 per cent chord station. The usual result is violent pitch-up and buffeting.

It's not that all GEMs are flatly limited to a forward speed of 100 knots. However, GEMs that are subject to the center-of-pressure shift will need stability augmentation or a design fix for operation at very high speeds.

Research into "overpowered" GEMs may well lead to designs that will have forward speeds of 150-200 knots. These will have enough power to operate above or jump out of the cushion and overcome any resulting drag factor.

## Operating envelope is expanded

If you give an air-cushion vehicle enough power for operation at the upper limits of the air cushion (with $H/D$ approaching unity), interesting things begin to happen. You find that you can operate over a wide range of $H/D$ and augmentation values. Inherent static and dynamic stability drop as you reach the upper limits of the cushion, and the vehicle becomes unstable in free air in the absence of aerodynamic forces or artificial stabilization.

Once you are able to get high enough off the ground, you therefore also should be able to tilt your vehicle in the direction of flight. Then the horizontal component of the air cushion's lift vector can be added to the propulsive thrust or serve as the only propulsive force.

A simple, easily operated two-control system should insure safe operation of a GEM of this type, which could be "trimmed" for conditions like cruise. The throttle setting would determine the operating height, and a "stick" could be the control actuating the mechanisms producing the tilting moments. The deflection of the "stick" would determine both direction and speed. Tilting the vehicle and its air intake also should decrease the momentum drag of ingested air.

## Interesting possibilities arise

This concept of a high-powered low-augmentation vehicle raises some interesting possibilities:

- *Stability*—light gyroscopic systems or aerodynamic stabilization schemes could be used for operation on the fringes of ground effect air and in approaching free-flight speeds.
- *Control*—the vehicle could be turned, stopped, and reversed just by tilting, which would change the direction of the cushion's thrust vector.
- *System Integration*—The jet nozzle exhaust and so the vehicle tilt angle could be controlled automatically to compensate for payload, height, and speed changes.
- *Structures*—Extremely strong and light aerodynamic structures could cut down power requirements and increase the payload capabilities.

The high-augmentation vehicle could be used to transport very heavy payloads flying close to the ground. Lightened, the same vehicle could step up higher on the air cushion for hedge-hopping operations and fast ma-

***more on next page***

## U. S. GEM System and Subsystem Programs: Contractors and Government Agencies

**Army**

Aeronutronic Div., Ford Motor Co., Los Angeles, Calif.
Avro Aircraft, Ltd., Malton, Ont. Canada
Princeton U. Forrestal Research Center, Princeton, N.J.
Vertol Aircraft, Horton, Pa.

**Bureau of Naval Weapons**

Convair Div., General Dynamics Corp., San Diego, Calif.
Gyrodyne Co. of America, Inc., St. James, N.Y.
Saunders-Roe Ltd., Cowes, Isle of Wight, England

**Bureau of Ships**

Hughes Tool Co. Culver City, Calif.
Martin Co., Orlando, Fla.
Stevens Institute of Technology, Hoboken, N.J.

**Marine Corps**

National Research Associates, College Park, Md.

**Office of Naval Research**

Aerophysics Co., Washington, D.C.
Bell Aircraft Corp., Buffalo, N.Y.
U. of California, Berkeley, Calif.
Cornell Aeronautical Laboratory, Buffalo, N.Y.
Hiller Aircraft Corp., Palo Alto, Calif.
U. of Iowa, Des Moines, Iowa.
Lockheed Aircraft Corp., Marietta, Ga.
Ryan Aeronautical Co., San Diego, Calif.
Thermoelectric Co., Ithaca, N.Y.
Vehicle Research Corp., Pasadena, Calif.
U. of Wichita, Kansas

**Other government agencies** interested in GEM development are Maritime Administration, Research Div., Washington, D.C.; National Aeronautics & Space Administration, Washington, D.C.; Office of Research & Engineering, Dept. of Defense, Washington, D.C.; Ordnance Tank Automotive Command, U.S. Army, Centerline, Mich.; Transportation Research & Engineering Command, U.S. Army, Ft. Eustice, Va.

**Other educational institutions** interested in GEM development include Catholic U., Washington, D.C.; U. of Toronto, Institute of Aerophysics, Toronto, Canada.

neuvering. It could be used as a weapons platform in close support of V-STOL free-flight vehicles operating at subsonic (or, some day, supersonic) speeds.

The free-flight V-STOL vehicle might use the air cushion for takeoff, very close support, and landing. In the air, it would be a "flying saucer," getting vertical pressure lift from its annular jets and aerodynamic lift from its motion through the air. Excess power would be used for thrust.

The biggest problem of such a free-flight vehicle is stability. Avro-Canada's work on a flying saucer should be of great help in this area.

The case for the high-powered low-augmentation GEM is based on our evaluation of theoretical and experimental data for vehicles using a peripheral jet, the most promising of the three basic types of air-suspension schemes. (The other two are the plenum chamber and the labyrinth seal.)

The actual lifting force ($T_A$) produced by a peripheral-jet "skimmer" is the summation of the basic thrust ($T_B$), or annular-nozzle momentum thrust out of ground effect, and the cushion augmentation thrust ($T_C$). Augmentation is a function of the ratio of the height off the ground ($H$) to the vehicle's equivalent circular diameter ($D$).

$T_A/T_B$ (sometimes called the cushion augmentation factor) is usually plotted against $H/D$ to illustrate the static characteristics of the air-cushion phenomenon. The point at which $T_A$ equals to $T_B$ (so that $T_A/T_B$ equals unity) represents the free-air hovering condition out of ground effect.

Factors like jet thickness ratio, discharge angle, pressure ratios, etc., all influence the augmentation characteristics of a particular annular jet nozzle. In general, though, the closer you are to the ground the greater, the free boost in lift. This is why most of today's skimmer R&D is concentrated on vehicles operating at $H/D$ values on the order of 0.1 and less.

Experiments show that the augmentation characteristics of some nozzle designs are at variance with those predicted by theory. Instead of a smooth decrease, you get a sharp drop in augmentation that levels off to a plateau—over a wide range of $H/D$ values—and then shows another sharp drop (*Fig. 1*).

### On-plateau operation is versatile

Assuming you start out with enough power—enough to operate just high enough to be outside the influence of ground effect—you can trade off payload against operating height over the entire augmentation range. Now, if you operate on the plateau, you need only a small change in augmentation (which represents only a small change in power) to produce a large change in operating height. A design operating on the plateau would be much more versatile than those limited to $H/D$ ratios of 0.1 or less.

Practically, you would probably want a vehicle designed to operate up to the edge of the plateau without ever hitting free-air capability. With a vehicle 10-12 ft in diameter, you would be able to skim around at a normal height of 5-8 feet, and you'd have very good off-road capability at less power than you would need for the same vehicle in free air. You would need an augmentation factor of 1.5-2, but you would still have an attractive proposition.—End

# The basic configurations

**by T. E. Sweeney and W. B. Nixon,** Dept. of Aeronautical Engineering, Princeton U.*

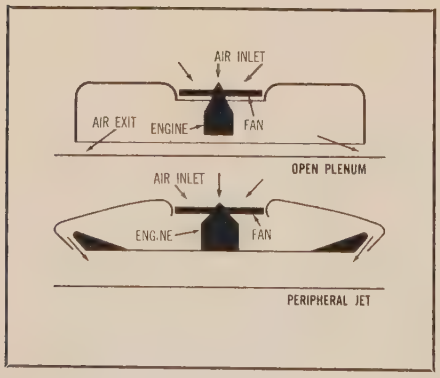



**FIGURE 3:** Interest in GEMs is centered on open-plenum designs and the more promising peripheral-jet vehicle.

RESEARCH ON GEMs seems to have boiled down to two general types: the open-plenum design, which has an open bottom, and the peripheral-jet design (*Fig. 3*). Each is supported by a self-generated cushion, or bubble, of low-pressure air.

In the open-plenum design, the thrust of a lifting fan is augmented by the product of the unit air pressure rise behind the fan and the base area. The pressure goes up as the opening between the plenum and the ground decreases, so that lift is augmented sharply as the vehicle approaches ground zero.

In a peripheral-jet design, the jet of air impinges on the ground to raise the base pressure of the trapped air under the vehicle just enough to turn the jet exhaust radially outward. As you get closer to the ground, the radius of curvature decreases, and the jet resists turning. This effect raises the base pressure and so increases the "lift."

Focusing the jet inward does essentially the same thing. The behavior of both basic GEM designs is modi-

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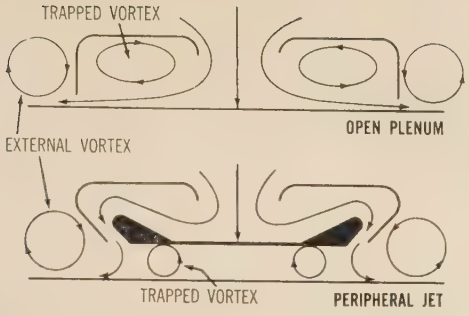


**FIGURE 4:** Trapped vortices reduce the lift characteristics of GEMs.

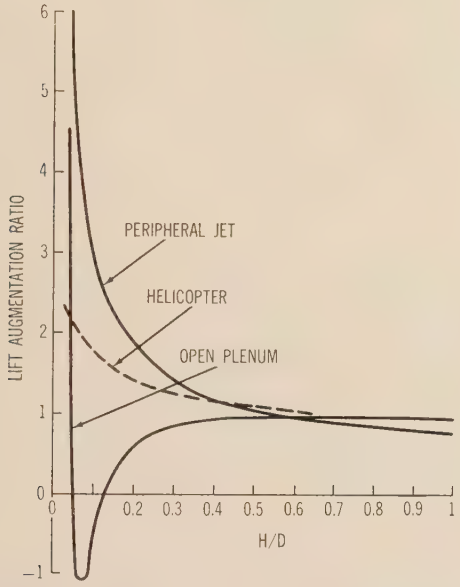


**FIGURE 5:** Typical experimental lift augmentation data.

fied by trapped internal vortices that have the effect of reducing the base pressure and so the lift *(Fig. 4)*.

The lift loss is significant for both designs, and apparently greatest for the open-plenum type. Depending on the configuration and vehicle height off the ground, the vortices can actually produce a negative lift *(Fig. 5)*.

Very little is known about the forward-flight characteristics of open-plenum machines. For peripheral-jet designs, on the other hand, a fair amount of conflicting data is being piled up.

Some experiments indicate that the lift decreases at low forward speeds. Others show that it increases with speed. But still others reveal that both speed increases and decreases can produce both lift increases and decreases.

The explanation for these contradictory results appears to lie in the fact that, in forward flight, the vehicle begins to act as a wing. The amount of positive or negative lift produced by this "wing" depends on the strength of the peripheral jet relative to the forward

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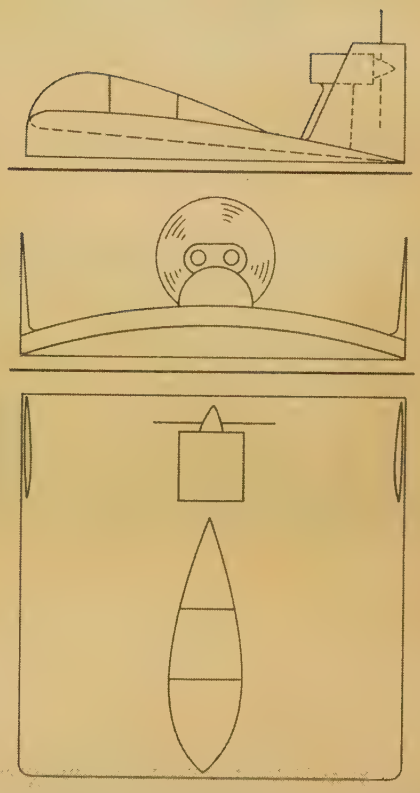


**FIGURE 6:** Typical lift characteristics of a conventional plane with a peripheral jet exhaust in each wing.

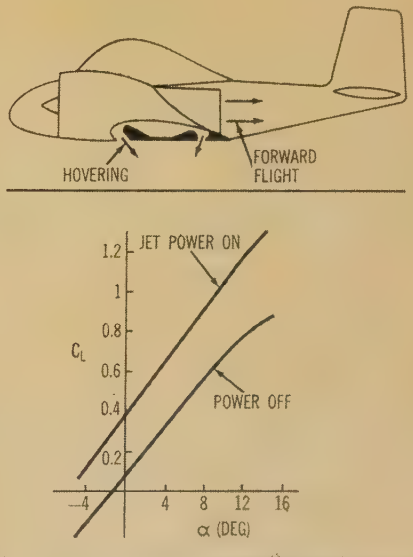
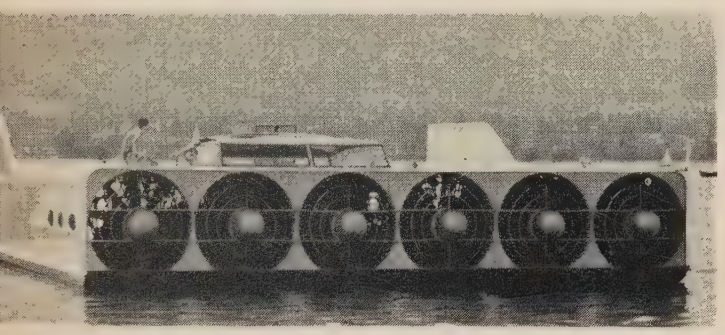



**FIGURE 7:** In the ram-wing vehicle, the ground effect provides lift and reduces the induced drag.

**GEM-1,** built by National Research Associates and Pegasus, was the first air-cushion vehicle to be tested by the Marines. Measuring 14x8x3 ft, it uses a single peripheral jet.



**PRESSURE DROP** by labyrinth sealing is used in the GEMs developed by Carl Weiland in Switzerland (above). His designs have attracted some attention in the U.S. Below: Gyrodyne's Model 55 GEM, developed for BuAer, made its first flight last October.

flight speed. In view of this situation, why shouldn't you combine the features of a peripheral jet with those of a conventional airplane? What this approach leads to is a GETOL, or ground effect takeoff and landing vehicle.

Wind tunnel tests show that a conventional airplane's longitudinal static stability remains unchanged when peripheral jet power is applied. However, there is a definite trim change. The jet produces a strong circulation, or lift increase, comparable to that due to a sharp flap deflection (*Fig. 6*).

An approach that can be called radically different even in the unconventional GEM field has been taken by the proponents of the "ram-wing" vehicle (*Fig. 7*). Little is known about this type other than that the ground effect seems to provide some lift and a substantial decrease in drag. Apparently no more than slight negative dihedral angle at the leading edge of a low-aspect-ratio wing is needed to produce enough ram pressure to generate lift. The ground effect seems to reduce the induced drag. For some unknown reason, the ram-wing design seems to be both statically and dynamically stable despite its lack of conventional stabilizing surfaces.

No matter what type of GEM they are working on, engineers face two big problems: How do you stabilize a GEM, and how do you control it?

Open-plenum GEMs have positive static stability at the low heights at which they have been tested to date. Peripheral-jet designs, which so far look more promising, appear to be statically stable until they climb to 0.05-0.06 $H/D$. Then they become neutrally stable and eventually statically unstable (unless modified).

Adding a second, concentric jet to the base of the machine (inboard of the periphery) or adding radial jets improves the static stability. This improvement, however, is somewhat offset by a loss in hovering performance.

The problem with control is that you must be able to generate enough horizontal force in any direction to resist skidding in turns and to provide braking. At high forward speeds, aerodynamic control surfaces can be used to generate the side forces. But what about low speeds, especially over land? (The question is less urgent for operation over water, which requires less control—there are fewer obstacles to go around and you can afford wide skidding turns and gradual stops.)

## GETOLs show hovering instability

Static hovering instability is probably doing more than any other problem to hold up the development of an acceptable GETOL. A successful GETOL must hover at a high percentage of the chord off the ground. First experiments have only confirmed the suspicion that GETOLs lack longitudinal hovering stability at such heights.

High speed GEM operation over water seems closest to reality. Until recently, it had been speculated that the momentum drag of ingested air would be so great as to put a practical limit on flight speed. More recent studies, however, show that this drag term is somewhat smaller than had been predicted.

Since a GEM can be an effective wing at high speeds, it may be possible to take some of the air normally used for suspension and apply it for propulsive thrust. In the end, the best answer might well be a combination of the peripheral jet and the ram wing.—End

**References**—E. A. Fradenburgh, "The Helicopter as a Ground Effect Machine;" Princeton U., Ground Effect Symp. Proc., Oct. '59. W. Z. Stepneiwski, "Performance Possibilities of Subsonic Airplanes Taking Off and Landing on the Ground Cushion;" Princeton U., Ground Effect Symp. Proc., Oct. '59. T. J. Kaario, "The Principles of Ground Effect Vehicles;" Princeton U., Ground Effect Symp. Proc., Oct. '59. Nixon & Sweeney, "Some Qualitative Characteristics of a Two Dimensional Peripheral Jet;" Princeton U., Aero. Dept., Report 484, Sept. '59. Nixon & Sweeney, "Preliminary Flight Experiments of the Princeton University 20-Foot Ground Effect Machine;" Princeton U., Aero. Dept., Report 506, Jan. '60.

# GEMs:

## specifications and performance

**Bell Air Scooter**—This small air-cushion vehicle is a research project that was started last June. It uses a 12 hp, two-cycle motor-scooter engine, which turns a fan of 30 in. diameter to lift the machine about 2½ in. off the ground. Built of fiberglass and aluminum, the Air Scooter is simple to operate and maintain—a four-year-old girl has successfully flown an electrically powered prototype, says *Bell Helicopter Corp., P. O. Box 482, Fort Worth 1, Texas.*

Length, 85 in.; width, 53 in.; height, 30 in.; fan diameter, 30 in.; empty weight, 160 lb.; max and cruising speed, 25 mph; range, 20 miles.

**Convair GEM**—Under Navy contract, *Convair Div., General Dynamics Corp., San Diego 12, Calif.,* has been developing work on nuclear-powered GEMs that would also use gas turbines and be able to span oceans. These circular machines would operate about 12-15 ft above the surface and have a diameter of 400 ft. Preliminary requirements called for a cargo capacity of 1,000,000 lb and a speed of about 100 knots. A single, continuous annular jet extends along such a vehicle's periphery. The base pressure would be 30 psf. Both square- and radial-truss structures are being considered. A planform 720 ft in length and 245 ft in width is also being studied. Construction would rely almost entirely on aluminum alloy. For the hot-air, or exhaust, ducts and other hot sections near the engines and reactors, steel or titanium would be required. The main structural grid would be built up of truss-like longitudinal and transverse beams. Aluminum alloy tubing or an open-beam structure would be used. The vehicles being considered would span the oceans; their minimum endurance at a design speed of 100 knots would be about 30 hours. The total required power for a transoceanic flight would be 150,000 hp. The propulsion system would include the reactor shield assembly with plumbing and radiators; turboprop engines, lift fans, gas generators, and associated ducting; and the engine controls. A 20-man crew would be carried.

Overall length, 459 ft; diameter, 400 ft; overall height (at fins), 62.5 ft; fuselage height, 29 ft; gross weight, 4,000,000 lb; payload, 1,000,000 lb; speed, 100 knots; minimum endurance, 30 hr; hovering altitude, about 12-15 ft.

**Curtiss-Wright 2F-1780**—This proposed air boat, is designed to transport cargo or personnel over land or water, says *South Bend Div., Curtiss-Wright Corp., 701 West Chippewa Ave., South Bend 23, Ind.* Two low pressure vertical-

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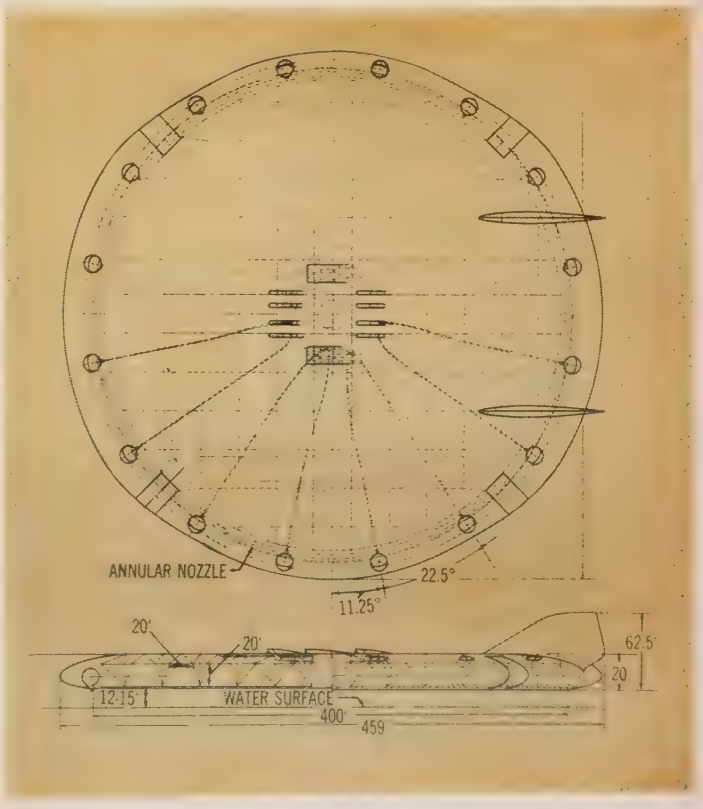
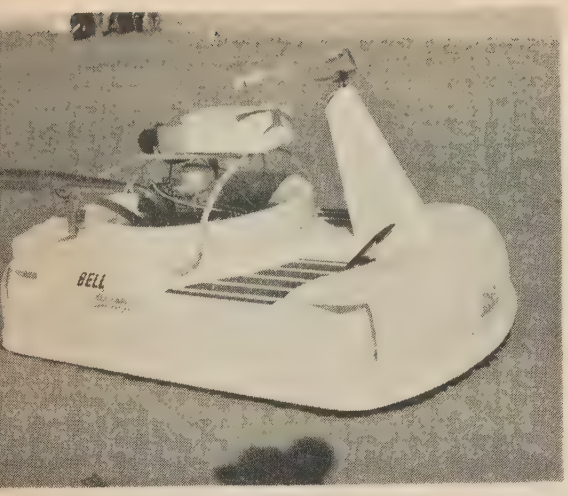
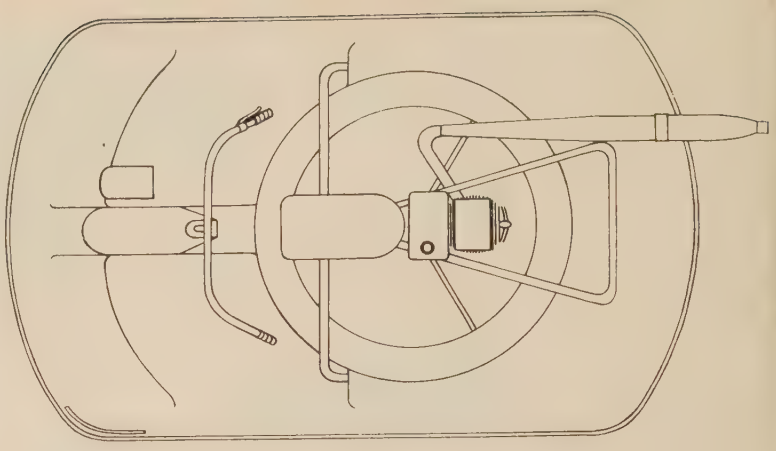
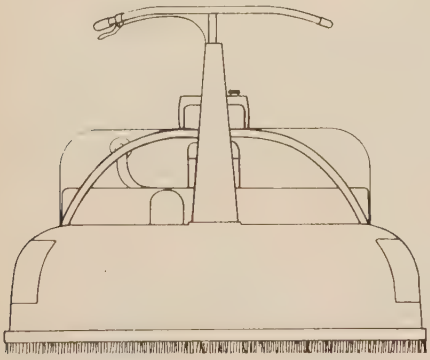
**Convair GEM**

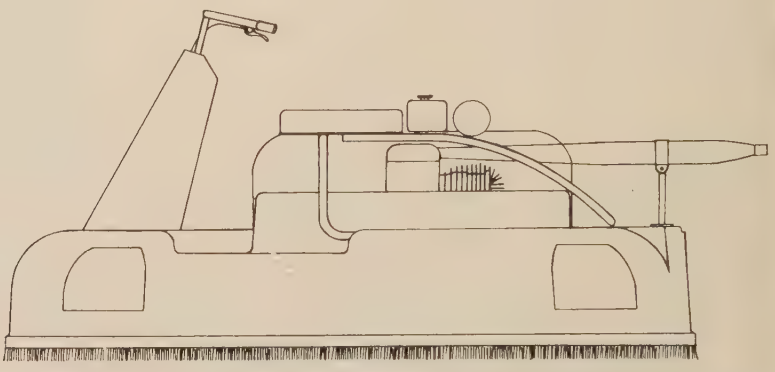




Bell Air Scooter





axis fans, each powered by a C-W C9 engine, supply air to a large lift chamber that takes up the full width and most of the 87-ft length of the vehicle. Air from the chamber is released through controllable louvers on the sides of the boat. It is ejected clear of the air boat to provide thrust for maneuvering and propulsion. The louvers can be controlled to make the boat go forward, backward, sideways, or turn on its axis. They are also used for braking in any direction. The louver control lever can be set to neutral (for hovering), forward (for forward movement), and rearward (for reverse). A turning bar controls the turning of the boat by overriding the lever positioning of diagonally opposite louvers. The body is a combination truss and monocoque construction of aluminum. The cargo floor is stressed to take a load of 100 psf.

Length, 87 ft; beam, 34 ft; cargo space, 31×41×4 ft; payload, 14,000 lb; guaranteed speed: over land—30 mph, over calm water—28 knots.

**Curtiss-Wright 2500 Air Car**—This GEM travels at a height of up to 12 in. over any unobstructed terrain, flying forward, backward, or sideways, turning on its own axis. C-W says the machine is inherently stable, and that the controls are used only for direction, changes and braking. Air is used for suspension, propulsion, and braking. Using a deflector-plate, or annular-slot, system, the Air Car requires a minimum air flow for any given performance. As air is expelled through the slot, additional height is gained from the downward directed exit momentum. The lower air flows of the deflector-plate design appreciably reduce the inlet momentum drag and higher speeds. About 1/10 psi of air pressure is maintained under the vehicle. An automotive-type steering wheel and conventional throttle controls are used. Flotation equipment is built into the structure so that the vehicle can float on water. The body is aluminum and fiberglass on a tubular aluminum frame. The deflector plates control spray in over-water operation.

Length 21 ft; width, 8 ft; height 60 in; weight, 2500 lb; payload, 1000 lb. Fuel, two 20-gal tanks; speed, 60 mph; endurance, over two hours; hover height 6-12 in.

**Gyrodyne 55**—This one-man ground-cushion machine of the annular-jet type is powered by a 1600 cc, four-cycle, four-cylinder, 72-hp, Porsche engine. It made the first flight—under a Navy contract—last October. Designed by *Gyrodyne Co. of America, Inc., St. James, N.Y.*, as a test bed for studies, feasibility and aerodynamic aspects of the annular-jet vehicles that measure up to several hundred feet diameter and operate at 100 mph or better, the bell-shaped craft is made of aluminum spinnings. Its diameter is six feet. The rear engine drives axial flow fan. Air is ducted beneath the fan to an annular-jet in the periphery of the base and to radial slots in the base. The annular-jet raises static pressure under the base, providing lift augmentation. The radial jets tend to compartmentalize the pressurized air under the base, giving the machine positive static stability. The fuselage is the modified forward end of an XRON-1 rotorcycle. It includes the pilot seat,

control stick, rudder pedals, and throttle. The pilot's longitudinal, lateral, and directional controls are conventional copter types. The throttle is to the left of the pilot, in the position of the collective pitch control in a copter. Cyclic stick and rudder pedals are connected to a series of vane in the annular jet exit to provide control.

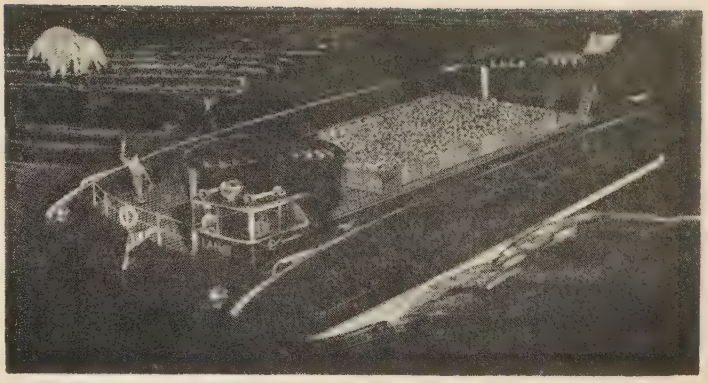
Length, 9 ft 1 in.; width, 6 ft.; height, 5 ft 3 in.; fan diameter, 24 in; gross load, 800 lb; useful load, 265 lb; fuel, 3 gal.

**Princeton X-3**—Circular in planform, the X-3, designed by *Forrestal Research Center, Princeton U., Princeton, N.J.*, under Army contract, has a single annular-jet and four radial slots. A vertically mounted 44-hp engine turns a horizontal Sensenich prop, while a 5-hp Power Products engine drives a tail rotor installed in a fin. The radial slots have been sealed off, because at the heights achieved so far they haven't been needed for static stability. The tail rotor provides control about the normal axis. Its engine swivels through 180 deg and is mechanically connected to the rudder pedals. Control vanes in the annular nozzle provide longitudinal and lateral control. The vanes operates as butterfly valves when turned from the normally open position. A group in the forward periphery produces nose-down pitch, and others in the aft periphery, nose-up pitch. Tip vanes provide right and left roll. An electric servo actuates each set of vanes and is controlled by a formation stick in the cockpit. Power will be increased to 180 hp to permit higher hovering heights of up to three feet and speeds of up to 40 mph.

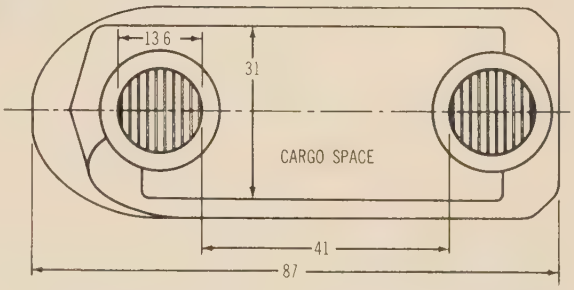
Overall diameter, 20 ft; diameter base, 18 ft 2 in.; slot area, 19.3 sq ft; inlet area, 12.5 sq ft; prop diameter, 4 ft; gross weight (incl. pilot & fuel), 1070 lb; empty weight, 850 lb; max speed, 20-25 mph; max ground clearance, 12-14 in.

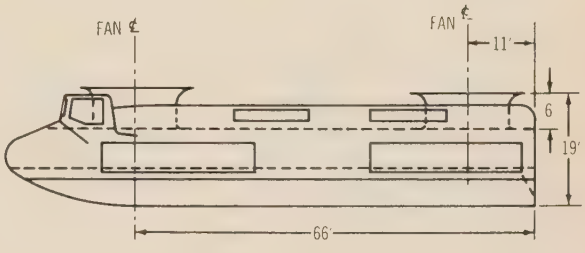
**Saunders-Roe SR-N1 Hovercraft**—An experimental vehicle, the SR-N1 Hovercraft can carry 20 equipped marines, or about 4000 lb payload. Last July it crossed the English Channel. Built on the jet-curtain principle by *Saunders-Roe, Ltd., Osborne East Cowes, Isle of Wight,* the Hovercraft has an Alvis Leonides 523/5 piston engine limited to 450 hp. A four-bladed axial fan supplies air for the jet curtains, which are ejected through nozzles facing towards the center of the vehicle.

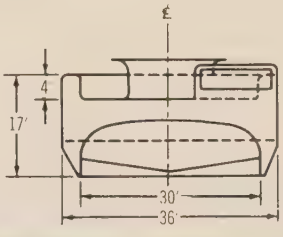
Length, 32 ft; width overall, 25.6 ft; height, 10 ft; fan diameter, 7 ft; cushion loading (normal), 16.5 psf; gross load (normal), 8700 lb; overload, 12,700 lb; useful load (2 crew), 400 lb; payload overload, 4400 lb; fuel capacity, 30 gal; max cruise speed (still air), 30 mph; range (still air), 25 miles; fuel consumption, 36 gph; hovering ceiling (in ground effect), 1.1 ft; hover height (4000-lb payload), 0.7 ft.



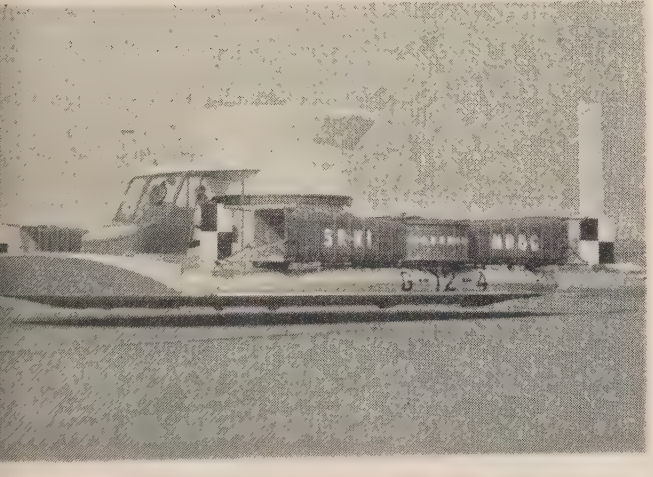
Curtiss-Wright 2F-1780



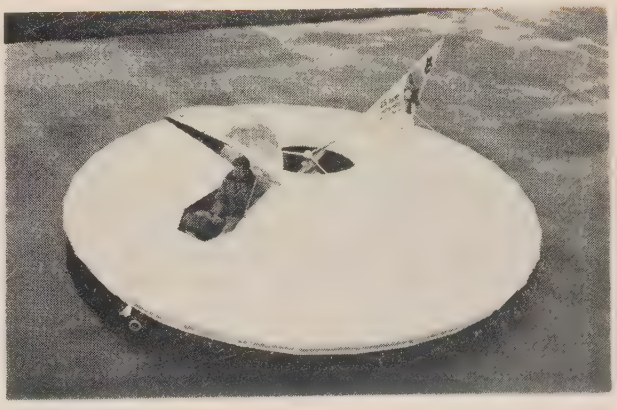




Saunders-Roe SR-N1

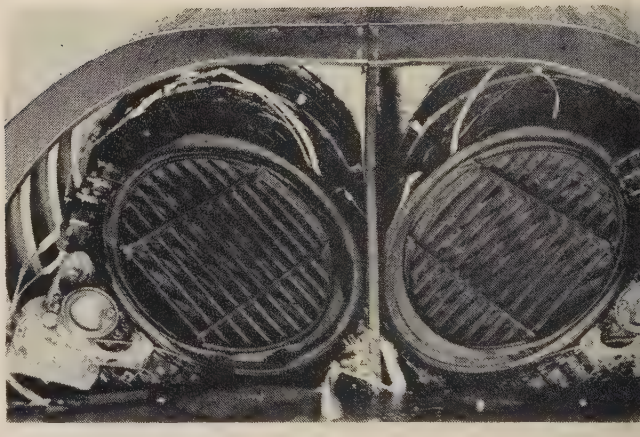


Princeton X-3



# V-STOLs: state of the art

- Gas turbine engines improve copter outlook
- Time is ripe for practical new V-STOL designs
- Pitching moment, efficient propulsion are key V-STOL problems



**HIGHLIGHTS** of Bell's X-14 jet VTOL test bed include reaction control used in hovering and low speed flight, when conventional controls are ineffective. Compressed air from two Armstrong-Siddeley Viper engines is piped

**by Irwin Stambler,** Associate Editor

V-STOL design, which has been marking time in the recent past, finally appears to be headed towards some definite decisions on advanced hardware in the next few years. One reason for optimism lies in the current, comprehensive NASA evaluation of V-STOL parameters for the armed forces.

The way things stand now, researchers at NASA's Ames Lab told SPACE/AERONAUTICS, we lack data even for many areas of conventional copter design. The military has a wide range of test beds, covering just about all the major V-STOL principles in the field. NASA's aim is to use these craft to provide basic data for designers of practical optimum configurations. The studies they have completed so far, these researchers state, show that soon the time may be ripe for one or more production prototypes in various areas of advanced V-STOL design.

In the immediate future, though, the conventional copter will continue to be the workhorse. What's more, Stanley Hiller, president of Hiller Aircraft, told SPACE/AERONAUTICS, the reciprocating engine will be used in copters much longer than we've previously thought. Hiller notes that piston engines are logistically easy to support, reliable, require little fuel, and can take wide changes of conditions with a minimum effect on operation. Turbines, says Hiller, by comparison still pose problems. The engine manufacturers therefore are bringing out new generations of piston powerplants.

Nonetheless, the gas turbine is pointing the way to the next major forward step for copters—in the next few years, commercial jet copters are slated to enter service the Aero-Space Industry Association recently noted, a copter can carry 40 per cent more payload over a 100-mile range with a gas turbine than with a piston engine of the same horsepower.

There's no doubt that there has been a tremendous improvement in turbine thrust-weight ratio—up to values of around 10. Both NASA researchers and vehicle designers agree, however, that still more improvement is needed, particularly if many of the ad-

vanced VTOL concepts are ever to prove practical. Other needs, J. B. Nichols, of Hiller, states, include a wider variety of sizes in turboshaft engines and gearboxes with provisions for cross-shafting between engines.

Work is continuing on improved rotor structures and blade configurations as well as on such novel approaches as blowing-type BLC. Typical of the structural trends is the current study of blades for small copters whose trailing edges use a foam core and fiberglass skin.

BLC may solve the key copter problem: the speed limitation due to vibration and the lack of control caused by the entrance of a retreating blade into the stall regime. NASA studies on H-21 blades show that BLC near the leading edge provides marked increases in forward speed, provided the total drag area is kept below 20 sq ft. Tip speed ratios on the order of 0.46 without stall were obtained; these are comparable to speeds on the order of 200 mph for a given drag area. NASA got its results with cyclic blowing on the retreating blade at flow rates of about 1.5 pps and about 35 air hp. It's results, NASA states, show that substantial reductions are needed in overall copter drag if the stall delay is to give a worth-while speed increase at reasonable power.

Many other advanced copter concepts are also in the R&D stage. One is the Sikorsky compound design, which used both rotors and fixed wings—as well as supplementary powerplants — for potential forward speeds of 300 mph. Increased range is the aim of Vertol's floating-wing design, in which stub-wing fuel cells are attached to the fuselage with hinges, so that no loads are transmitted to the main structure that would require beefing up. The basic idea is for the wing to support itself by aerodynamic lift. Turbine-driven flying cranes also seem likely to come into their own in the next few years.

Among unconventional rotor types, the unloaded-rotor Rotodyne has already attained speeds of over 200 mph in forward flight. NASA has also been studying the unloaded-rotor concept of its V-STOL program. Besides rotor types, this program has covered vehicles using ducted fans, submerged fans, and jet reaction, useful in attaining stability and control over parts of the flight speed range:

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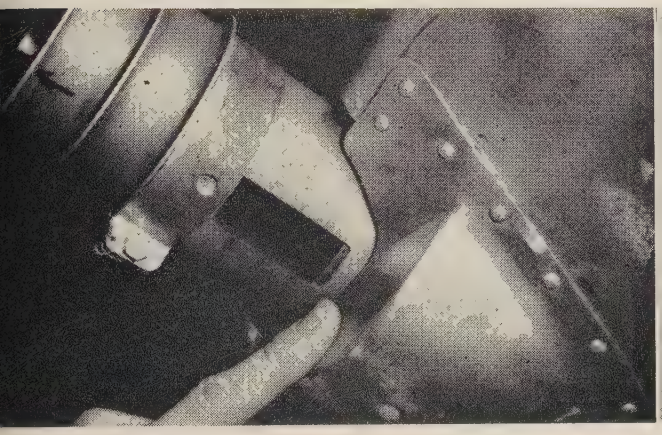
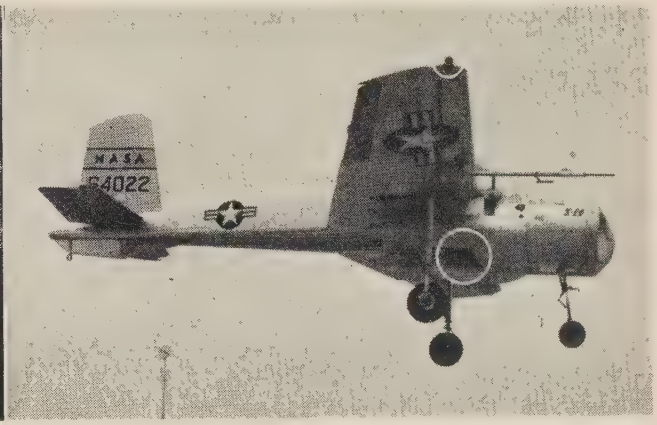
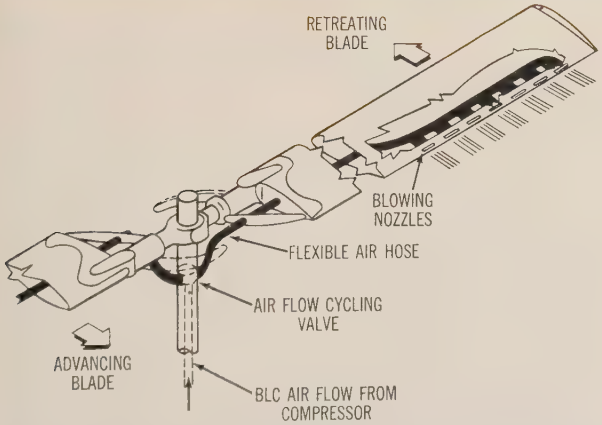
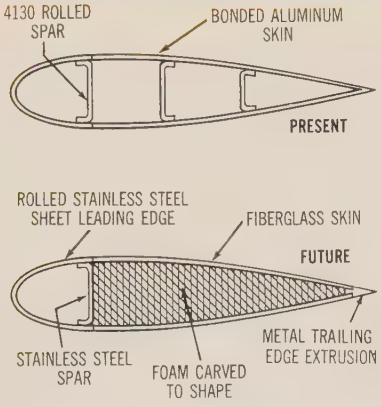


to outlets in the wing tips and the tail. The pilot controls the amount of air ejected through rectangular slots as well as its direction. Thrust deflection is provided by adjustable turning vanes in the bottom of the fuselage.

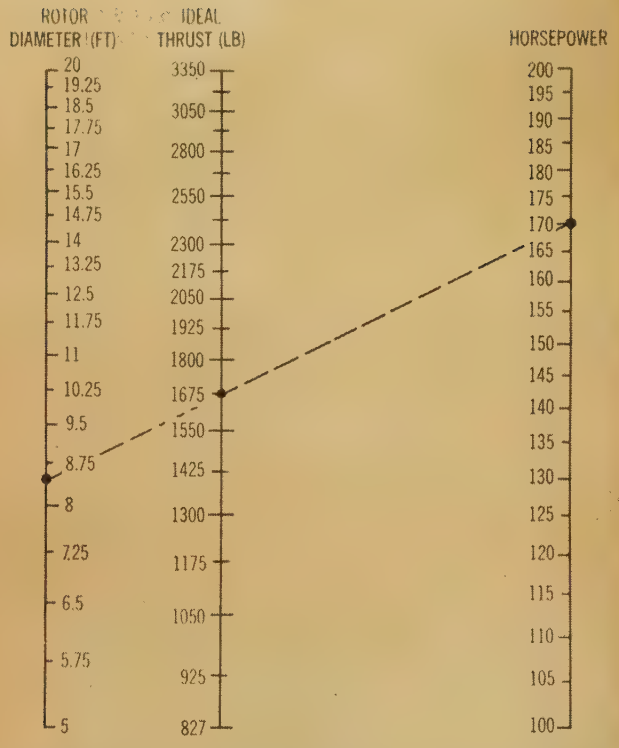



The inner vanes are fixed; the outer set can be rotated mechanically by the pilot. The relative positions of the two sets of vanes determine the flow direction of the engine exhaust gases.




**JET FLAPS** (left) are being studied for reducing retreating-blade stall, a major problem in copter design. Right: Trends in rotor blade structures are shown in sketches of present and possible future blade sections for the Hiller 12E. The bottom sketch shows a Parsons plastic-foam structure.




**NOMOGRAPH** for finding the approximate gross weight of a ducted-fan aircraft from the rotor diameter and the horsepower at the rotor shaft. The dotted line shows the solution for Chrysler's aerial jeep with two engines delivering 170 hp each to the shaft and a 8½-ft rotor diameter. At an efficiency of 0.7, each duct would produce 1170 lb static thrust. As a first approximation, Chrysler engineers took the vehicle gross weight as 2000 lb.

ing-edge flaps at low angles) has enough speed to carry all the load.

Problems with the XV-3 included large rotor flapping angles, possible mechanical instability at higher forward speeds, and instability in hovering flight in ground effect.

Among the solutions suggested by NASA are increases in cyclic pitch and in damping in pitch to get better low speed longitudinal control. Increases in the value of pitch flap-coupling or more direct alignment of the rotor axis into the in-flow angles, it's noted, might relieve the flapping and mechanical-instability problems.

In propeller types, tilting wings, deflected slipstreams and BLC (or jet flaps) are all being studied by NASA. Tests on the Ryan Vertiplane (model 92) showed a craft of this type can hovering out of ground effect. However, when the plane is 4-6 ft off the ground, there is a strong nose-down tendency.

For pure tilt-wing designs, NASA studies show, the rate of descent at low transitional speeds is severely limited by the small stall margin for one-G level flight.

**NEXT GENERATION** of commercial 'copters is represented by designs like Sikorsky's twin-turbine S-61.

• The horizontal stabilizer was free to float through a large range of angles, depending on the downwash characteristics at the tail to minimize longitudinal stability problems.

• The rotor speed governor, which operated during airplane-type flight at more than 115 knots, minimized blade flapping instability at high advance ratios.

A major disadvantage of the XV-1's concept, states NASA, is the high drag of the unloaded rotor and hub, which increased the total drag by 80 per cent.

## Tilting rotor has few stall problems

Extensive wind tunnel and flight tests of the Bell XV-3 showed that the plane's tilting rotor has a number of good points. For instance, the low disk loading of the rotor states NASA, means that relatively little power is needed for hovering and minimizes rotor slip stream interference effects on the wing and other aerodynamic surfaces. Also, the transition from one flight mode proved easy, and there were no wing stall problems—the rotor can carry load until the wing (with the trail-

Large areas of stall occur at relatively low tilt angles, model tests show, in the region of the wing over the fuselage that lies between the slipstreams of the propellers. In wind tunnel tests, the stall caused severe model shake and tail-flow oscillations and buffeting. As a solution, NASA suggests a highly effective leading-edge device to increase the stall margin and so provide reasonable rates of descent.

France has an advanced deflected-slipstream vehicle in the Bréguet 940. The lift design of this plane is well advanced and could provide STOL performance if a sufficiently high power-weight ratio is achieved. The remaining problems are largely mechanical—proving the spanwise shafting freewheels and clutches. Lateral control is provided by differential pitch change on the outer of the four propeller.

A combination of deflected slipstream and tilting wing may prove to be the best approach. Ames plans to look into this possibility later this year, when it starts here on the Kaman K-16, a rebuilt Grumman Goose using a "rotor-prop" tilting wing.

Tests on a Stroukoff C-134A BLC transport at Ames

show that stability and control about all axis become increasingly worse at speeds below 70 knots. For such a design, it might be necessary to use counter-rotating-props to eliminate the large sideslip angles that occur with high thrust coefficients at low speeds.

For supersonic aircraft, jet flaps might provide STOL characteristics. Researchers state, however, that their studies to date show that the best region for jet flaps is around Mach 1.5—and that region probably will be passed over as we go directly to Mach 3+.

## Improved propellers are needed

It's generally agreed that a prime need for V-STOL propeller types is better propellers. The trouble is that a good low speed prop has high-aspect-ratio blades while a good high speed prop is short and stubby and has thin sections and a wide chord.

In a recent NASA series, wind tunnel tests were run on three radically different prop designs for a thrust angle of attack range from zero to 85 deg. The results, states NASA, show that propeller forces and moments at large angles of attack are a function of the advance ratio:

$$J = V/nd,$$

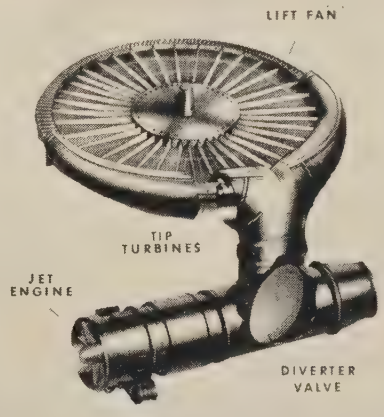
multiplied by the cosine of the thrust axis angle of attack:

$$J' = J \cos \alpha.$$

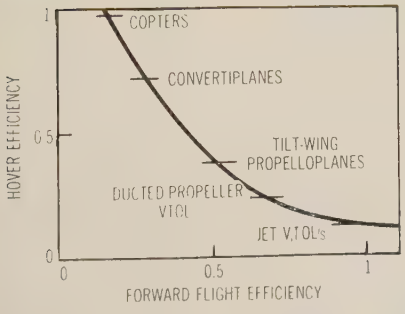
As the advance ratio increases, the critical thrust axis angle at which the variation of forces and moments ceases to be linear with $J'$ decreases.

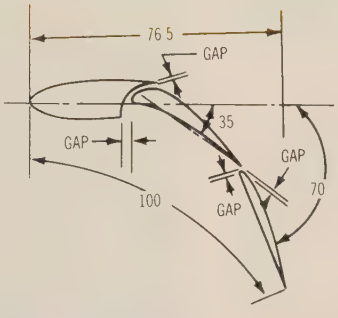
NASA's data show that, for transition at one-G level flight conditions, and low thrust angles existing prop data can be used in most cases for design by linear extrapolation. However, for descending flight at high thrust angles, the prop might be operating over the critical angle, and existing data cannot be used. Tests of ducted-fan designs show that quite different configurations are best for low and high speeds. A variable duct is feasible, but it adds weight and complexity. On the other hand, such designs as the Doak 16 tilted-tip-

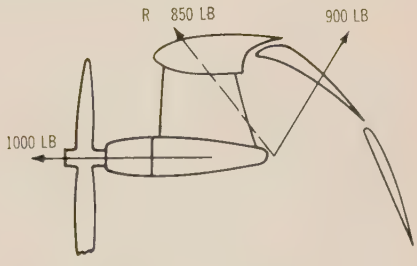
*more on next page*



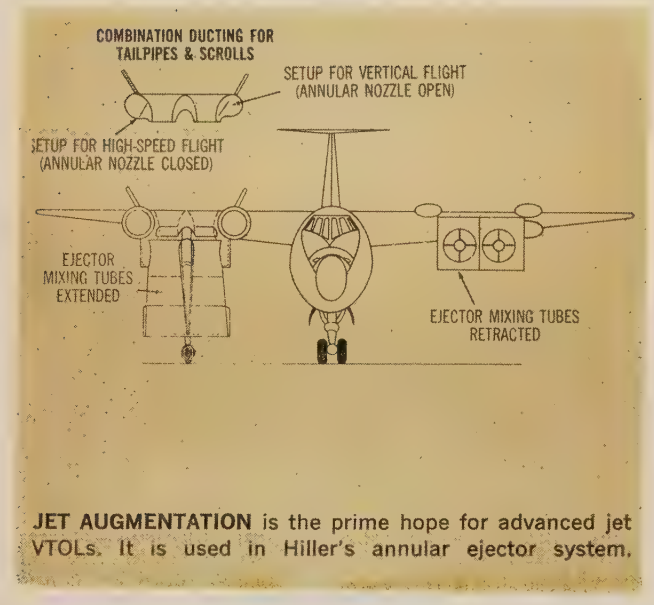

**VERTIFAN VTOL** design under development at Ryan Aeronautical is to be powered by a turbofan such as GE's lift-fan engine (right). The jet powering its fan, GE says, can be sized to the desired cruise thrust.




**HOVER EFFICIENCY** curve (left) by Nichols shows trade-offs for different V-STOL approaches. As Nichols notes, the helicopter is the only vehicle inherently suited for low speed flight—since it has large control forces to overcome gusts, precise control is possible. Right: Ryan's Vertiplane has provided extensive research data on deflected slipstream. The sketch of the Vertiplane wing shows the necessary compromise between large and small chords. The other sketch shows how about 15 per cent of an assumed 1000-lb forward thrust is lost in VTOL.


COMBINATION DUCTING FOR TAILPIPES & SCROLLS
SETUP FOR VERTICAL FLIGHT (ANNULAR NOZZLE OPEN)
SETUP FOR HIGH-SPEED FLIGHT (ANNULAR NOZZLE CLOSED)
EJECTOR MIXING TUBES EXTENDED
EJECTOR MIXING TUBES RETRACTED

**JET AUGMENTATION** is the prime hope for advanced jet VTOLs. It is used in Hiller's annular ejector system.

duct vehicle, NASA reports, seem to have a minimum of problems of mechanical reliability, control, etc. at speeds of up to 300-350 knots. The fixed pitch of the fan blades on the Doak model though, seems to limit this design's top speed to about 150 knots. Because of the tilt of the duct, there are also high-pitching-moment problems, but this might be solved by using vanes or other control devices in the ducts.

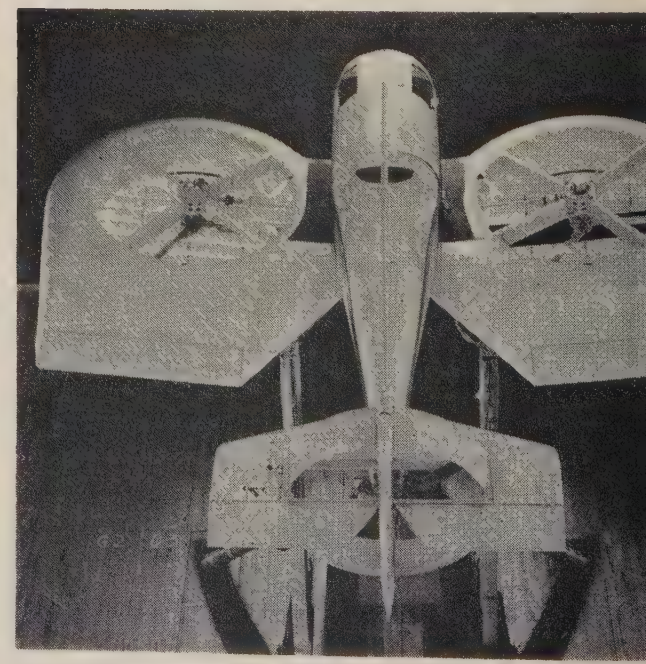
One of the more radical proposals for future VTOLs is the Collins Aerodyne, designed by Dr. Alexander Lippisch of delta-wing fame. Tests on this wingless vehicle at Ames are still in an early stage, but some results are in. With a jet of air blown over the elevator, for example, there appears to be enough control power throughout most of the transition speed range from 20 to 70 knots. At near-hovering speeds, the pitch control could be marginal for this type of vehicles if the moments of inertia about the pitch axis are greater than 500 slug-sq ft at a weight of 2500 lb (on the basis of an $\theta_{max}$ value of more than 0.35). A key problem, of course, is roll control—tests show it would be poor without some form of automatic stabilization.

Among the submerged-fan designs, the Vanguard Omniplane uses large, lightly loaded rotors in the chord plane of the wing. This plane is under test at Ames. Still in its early stages is the Ryan Vertifan, which is designed for a turbofan (such as GE's lifting engine).

NASA tests show that, for smooth transition form fan lift to wing lift, the wing probably should have high-lift flaps and leading-edge controls, so that the fan can be gradually unloaded with increasing speed. In addition, to provide enough thrust for acceleration, the thrust concurrently may have to be transferred gradually or in steps from the fan to the propulsive engine.

According to GE, the major advantages of the submerged fan (which can be installed in either the wing or the fuselage or in both places) is that the turbojet powering the fan is sized for the desired cruise

**VANGUARD OMNIPLANE** mounted in Ames' 40x80-ft full-scale wind tunnel. Lift is provided by the shrouded rotors in wings. For conventional forward flight, metal lids (left off in the top view) cover the wing's upper surface, and the plane is driven by the shrouded prop at the tail. A piston engine in the fuselage drives rotors and props through a transmission and clutch arrangement. The slipstream from the wing rotors can be deflected by vanes on the lower part of the wing.



thrust. During cruise, it therefore can operate at minimum SFC. A drawback of the submerged fan is that the only way to reduce the power required for hovering is to do work on a larger quantity of air. Any engine that changes the flow of a large mass of air in the hovering region unfortunately tends to cause pitching moments. Other possible disadvantages of fan engines are weight and structural problems involved in installation. Nevertheless, NASA researchers think the submerged fan point, looks promising for a wide range of missions.

The British Hawker P-1127 ducted-fan design is known to be a lightweight, low cost tactical strike-recon aircraft that can operate as a VTOL or STOL machine. It's Bristol Siddeley BE-53 ducted-fan engine has four nozzles, all of which can be swiveled to point down or to the rear. Two nozzles take the cold flow from the fan, the other two the hot flow from the exhaust. Normal, short, and vertical takeoff therefore are all possible.

The P-1127 is due to fly soon, and will be the first truly operational military VTOL. The engine intake will presumably be forward. For control in hovering, flush-mounted fans developed by Boulton Paul may be used. These fans are powered by turbine bleed air.

## Annular jet looks interesting

Another very interesting concept, probably much farther in the future, is the annular jet. Hiller, for instance, has been working on a design in which an augmenter is coupled to the exhaust of a valveless pulse-jet. The principle is that an intermittent flow through the augmenter is more efficient than a continuous one, since it provides a piston effect. Hiller reports that it has duplicated the static-thrust SFC of a conventional jet with an equivalent machine that has no moving parts. At present, however, designs like Hiller's are too bulky for aircraft.

NASA's tests on the Bell X-14 reaction-jet test bed have shown it to have weak control power in all axes for hovering. On the other hand, the jet reaction does not tend to excite disturbances on the vehicle, so that the craft is very steady. NASA now is working on converting the X-14 into a variable-stability-and-control test bed.

Several jet-reaction designs have been developed in Europe. One of the most effective is Snecma's approach, in which a single jet engine provides both lift and propulsive thrust. The French machine takes off in a vertical attitude and builds up acceleration so that the aerodynamics start functioning in the normal sense. For low speed control, an autostabilizer actuates jets that influence the effective shape of the main nozzle. Very high rates of climb can be achieved.

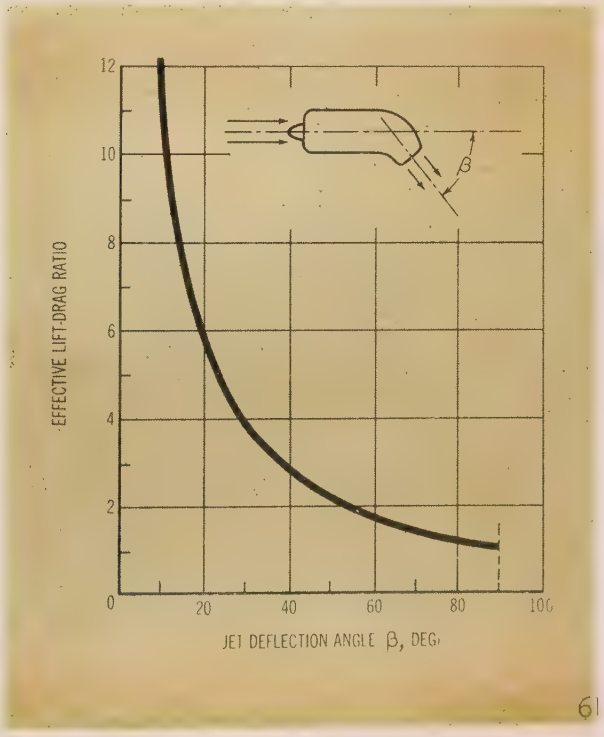
In Britain the Short SC-1 is well proved in hovering and low speed transition. However, the transition program apparently has fallen behind schedule. The SC-1's configuration, with the jets in the fuselage near the CG and a delta wing, makes the worst of the aerodynamic interaction problems.

NASA researchers told SPACE/AERONAUTICS that just about all the V-STOL concepts they have tested could be made to work. The major problems of just about all advanced designs are stability and control.

The future V-STOL spectrum appears to offer room for several classes of vehicles:

- For forward speeds of up to about 200 mph, conventional copters and rotor types similar to them look best.
- For observation and recon missions and for speeds of 200-400 mph, the choice probably will be between propeller types and ducted-fan designs; perhaps a combination, like the tilt-wing-deflected-slipstream configuration, will win out.
- For speeds beyond 400 mph, jet engine capability will be needed.—End.

**COLLINS AERODYNE,** designed by Alexander Lippisch, in Ames's full-scale tunnel. Louvered outlets on the craft's bottom direct a stream of air (drawn in by two props through a large circular duct in the nose) downward to provide lift. Effective lift-drag curve for such a vehicle was calculated by Nichols, of Hiller.



# VTOLs and STOLs:

## specifications and performance

*This listing is arranged alphabetically by manufacturer. The addresses of manufacturers for which several items are listed appear as part of the first items. The bold-faced numbers refer to the Reader Service Card opposite page 213.*

**Aer-Lualdi L-59**—Two firms are cooperating in developing and producing the L-59: *Aer-Lualdi & C., 95 Via Panama, Rome, Italy,* and Aeronautica Macchi Varese. The L-59 is a four-seat general purpose copter, has an all-metal structure with monocoque tail boom, and is equipped with tubular skids with retractable wheels. Powerplant is a Continental 10-470D of 260 hp. There is a two-bladed main rotor and a two-bladed, reinforced-plastic tail rotor. Dual controls are provided. No. **100** on Card.

Length overall, 40 ft 10½ in.; height 9 ft 8 in.; main rotor diameter, 34 ft 9½ in.; gross weight, 2645 lb; useful load, 1014 lb; fuel, 260 lb. Max recommended cruise speed, 93 mph; normal cruise speed, 80 mph; range (45-min reserve), 232 miles; range (with research), 240 miles. Service ceiling, 13,800 ft; hovering: in ground effect—9500 ft, out of ground effect—5575 ft.

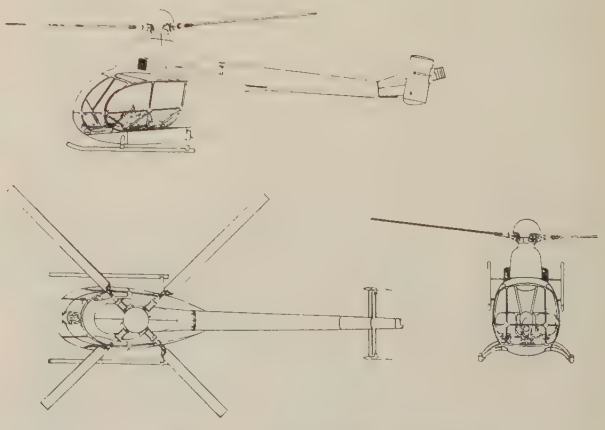
**Aerotecnica AC-12**—Designed by *Aerotecnica S. A., Velázquez 38, Madrid, Spain,* for training and liaison, this two-seat copter has a 168-hp Lycoming 0-360 B1A mounted over the cabin. The main rotor has three double-articulated, fiberglass-covered blades, each with a solid, machined dural spar as the leading edge and dural ribs and trailing edge. Klegecell plastic foamed resin compound fills the space between the ribs. The main rotor is driven direct from the engine gear box and clutch via a universal joint. The tail antitorque rotor is driven through a gear box and cardan shaft. No. **101** on Card.

Length overall, 27.23 ft; height, 8.56 ft; main rotor diameter, 27.89 ft; tail rotor diameter, 5.58 ft; disk loading, 2.7 psf; gross load, 1633 lb; useful load, 551 lb; fuel, 21 gal; max cruise speed, 87 mph; normal cruise speed, 72 mph; max range, 186 miles; normal range, 155 miles; fuel consumption, 7.4 gph; service ceiling, 13,123 ft; hovering ceiling: in ground effect—7874 ft, out of ground effect—3937 ft; SL rate of climb, 984 fpm.

**Aerotecnica AC-14**—Five-seat copter for transport, agricultural or ambulance operations, powered by a 400-hp Artouste II shaft turbine mounted over the cabin. No antitorque tail rotor is used, small movable tail fins being installed in its place. Forward speed is increased by the engine's residual thrust. The rotor has four blades of the same construction as the AC-12's. Fuel tanks are placed

Aerotecnica AC-12

Aerotecnica AC-14



under the seats. A skid-type landing gear is used. The cabin is sound-proofed. No. **102** on Card.

Length overall, 32.8 ft; height, 9.84 ft; main rotor diameter 31.66 ft; disk loading, 3.4 psf; gross load, 2645 lb; useful load, 1212 lb; fuel, 79 gal. Max cruise speed, 112 mph; normal cruise speed, 93 mph; max range, 400 miles; normal range 336 miles; fuel consumption, 25.4 gph. Service ceiling, 22,310 ft; hovering ceiling: in ground effect—16,076 ft; out of ground effect, 8200 ft; SL rate of climb, 1380 fpm.

**Bell X-14**—The X-14, designed for a test program that by now has been completed, marked a significant step in VTOL techniques. Using jet deflection, it can rise vertically, translate to 160-mph forward flight, hover and land slowly, all in the normal horizontal attitude. Two Armstrong Siddeley Viper jet engines are mounted horizontally side-by-side in the nose. Using the X-14 concept, *Bell Aircraft Corp., Niagara Frontier Div., Buffalo 5, N.Y.*, is now working on the supersonic, high altitude D-188 V-STOL fighter and the ducted-prop D-190 V-STOL.

Span, 34 ft; length, 25 ft; height, 8 ft.

**Bell HU-1A,- 1B Iroquois**—The first HU-1As were delivered to the Army just a year ago. Powered by a Lycoming T53 shaft turbine, the Iroquois was designed for a minimum of 1000 hours between overhauls by *Bell Helicopter Corp., P. O. Box 482, Fort Worth 1, Texas.* In the military version, the helicopter carries a pilot and five troops. The commercial Model 204 seats eight passengers. The main rotor and the tail rotor both have two all-metal blades. The landing gear is a skid type. Replacement times are: engine, 20 minutes; transmission, 40 minutes; main rotor and hub, 20 minutes; tail rotor hub and blade, 30 minutes; oil cooler, 30 minutes; main generator, 10 minutes; battery, 5 minutes. No. **103** on Card.

Length overall, 42 ft 8 in.; height, 11 ft 2 in. (-1A), 12 ft 5 in. (-1B); main rotor diameter 44 ft, tail rotor diameter, 8 ft 6 in.; gross load, 5800 lb (-1A), 6600-8000 lb (-1B); useful load, 1950 lb (-1A), 2200 lb (-1B); fuel, 125 gal (-1A), 166 gal (-1B). Max cruise speed, 120 mph (-1A), 138 mph (-1B); range, 210 miles (-1A); fuel consumption, 77 gph (-1A). Normal cruise speed, 115 mph (-1A), 126 mph (-1B); range 210 miles (-1A), 230+ miles (-1B); fuel consumption @ 6000 ft, 73 gph (-1A). Service ceiling, 17,000 ft; hovering: in ground effect, 14,000 ft; out of ground effect, 11,500 ft (-1A), 12,500 ft (-1B), SL rate of climb, 2100 fpm.

**Bell 47J-2 Ranger**—A four-seat version of the 47G helicopter. Designed for executive or utility use, it is powered by a Lycoming VO-540 rated at 305 hp and de-rated to 240 hp. The pilot is stationed centrally. The main rotor blades are metal. Hydraulic boost controls comparable to automotive power steering. The fuel system has twin stream-

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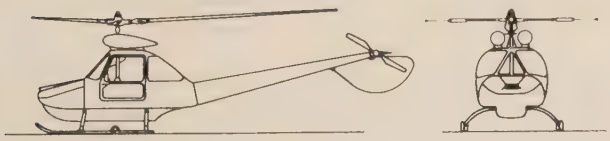
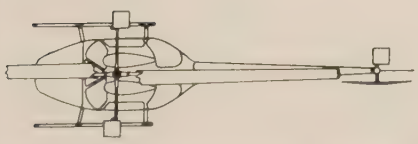
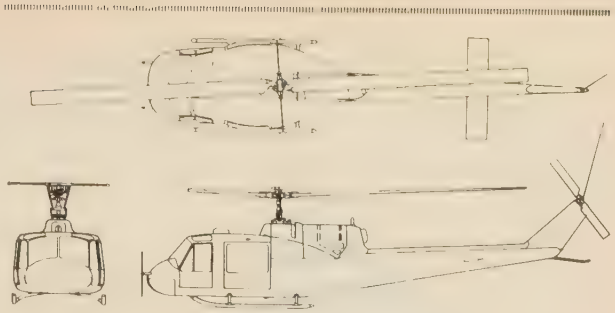
Aer Lualdi L-59

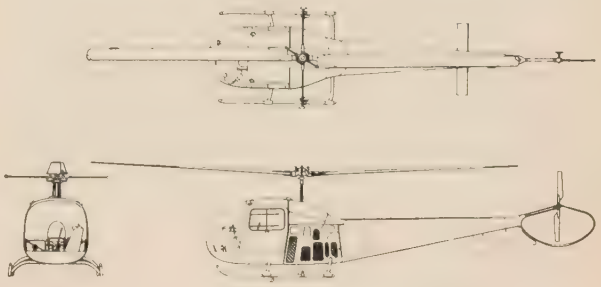






Bell HU-1 Iroquois

Bell X-14

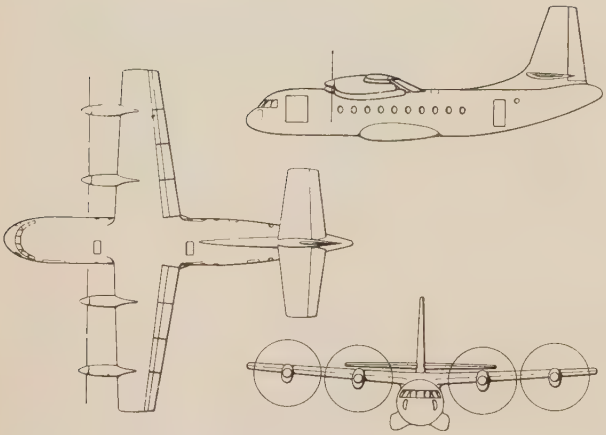


Bell 47J-2 Ranger

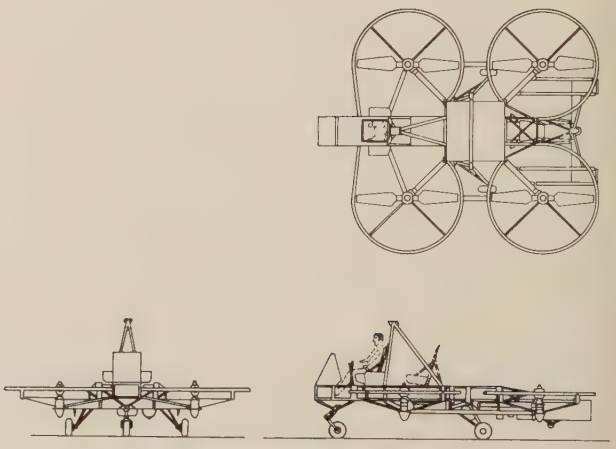
Bensen B-9 Little Zipster

Bensen B-8M Gyro-Copter

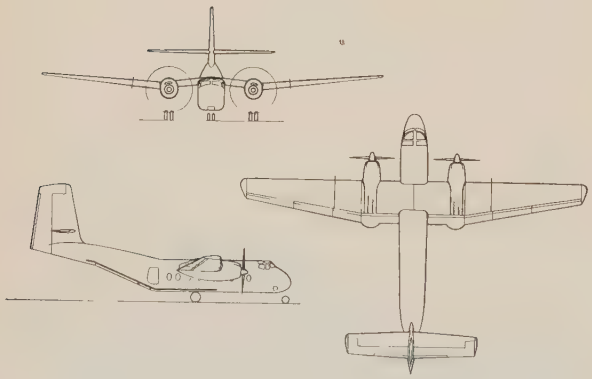
Bensen B-10 Prop-Copter



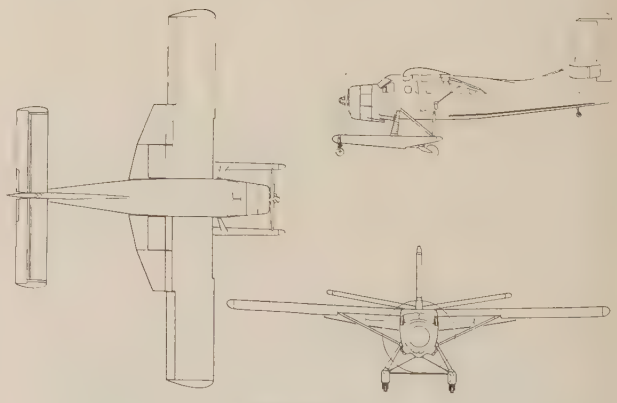
Breguet 942



Curtiss-Wright VZ-7AP



De Havilland DHC-4 Caribou



De Havilland Otter

lined CG fuel tanks with 48 gal capacity. A free-wheeling unit disengages automatically on engine failure. No. **104** on Card.

Length overall, 32 ft 5 in.; height, 9 ft 4 in.; main rotor diameter, 37 ft 2 in.; tail rotor diameter 5 ft 10 in.; gross load, 2850 lb; useful load, 1130 lb. Max cruise speed (45-min reserve), 105 mph; normal cruise speed (45-min reserve), 92 mph; range (45-min reserve), 239 miles; fuel consumption, 18.4 gph; service ceiling, 12,000 ft; hovering ceiling (in ground effect) 8450 ft; SL rate of climb, 630 fpm.

**Bensen B-8M Gyro-Copter**—The Gyro-Copter, designed by *Bensen Aircraft Corp., Raleigh-Durham Airport, Raleigh, N.C.*, is powered by a 72-hp McCulloch 4318E air-cooled engine. It has the same aluminum tubing in the fuselage structure as the B-9 and a tricycle landing gear with an auxiliary tail wheel. For control, there is an overhead azimuth stick for cyclic pitch (but no collective pitch control), rudder and nose wheel steering, throttle twist grip, and nose wheel brakes. Propeller is a Banks-Maxwell 45-24 pusher type made of birch. The unpowered rotor is a Bensen G2 airfoil with a thickness ratio of 0.01 and a chord of seven inches. Crew of one. No. **105** on Card.

Bolkow Bo-103

Borgward Rolibri I

Length overall, 21 ft; height, 6 ft 4 in.; main rotor diameter, 21 ft; tail rotor diameter, 45 in.; gross load, 500 lb; useful load, 250 lb; fuel, 6 gal. Max cruise speed, 85 mph; normal cruise speed, 60 mph; normal cruise range, 130 miles; max cruise range, 100 miles. Service ceiling, 16,500 ft; SL rate of climb, 2000 fpm; takeoff distance over 50-ft obstacle, 300 ft.

**Bensen B-9 Little Zipster**—A "pure" coaxial helicopter powered by a 70-hp Mercury MK-78 engine using automotive fuel. Controls include overhead azimuth stick (joystick is optional), rudder pedals for yaw control twist grip throttle on the left handlebar, and manual push-pull choke. There is no collective pitch control. Main structure is 6063-T6 aluminum tubing in all-bolted construction, using AN-4 bolts in all primary structure. There are no welded, brazed, glued, riveted, or bonded joints in the primary structure. Accommodates one pilot. No **106** on Card.

Length overall, 22 ft; height, 11 ft 6 in.; rotor diameter, 22 ft; gross load, 800 lb; useful load, 415 lb; fuel, 11 gal. Max cruise speed (SL), 65 mph; range, 120 miles; normal cruise speed, 55 mph; range, 150 m. Service ceiling, 12,500 ft; hovering ceiling—in ground effect, 9000 ft; out of ground effect, 6200 ft; SL rate of climb, 1200 fpm.

**Bensen B-10 Prop-Copter**—This VTOL of the "flying jeep" type has a rectangular, vertical frame. Powered by two McCulloch 4318A 72-hp engines, it has two lifting rotors fore and aft. Stick and rudder controls move air deflectors under the rotors. The B-10 is in the development stage.

Length overall, 144 in.; height, 54 in.; width, 72 in.; rotor diameter, 54 in.; gross load, 650 lb; empty weight, 350 lb, useful load, 300 lb; fuel, 6 gal. Max cruise speed (SL), 60 mph.

**Bolkow Bo-103**—From its non-flying Heli-Trainer pilot training simulator, *Bölkow-Entwicklungen KG, Ottobrun, Bavaria, West Germany,* has developed the lightweight, single-seat Bö-103 copter. The Heli-Trainer was designed to provide a practical training for helicopter pilots at the lowest possible cost and without accident risk. Mounted on a tripod or float, it can turn and change its attitude and go through all the maneuvers of a copter without danger of overturning. The fuselage is a simple steel-tube type. The main rotor blade is made of glass-bonded plastic with a foam core. A large counterweight on a stabilizing bar balances the rotor. The powerplant is a two-stroke, three-cylinder ILO L3x375 of 40 hp at 300 rpm. No **107** on Card.

Length overall, 19 ft 5 in.; height, 9 ft 2 in.; main rotor

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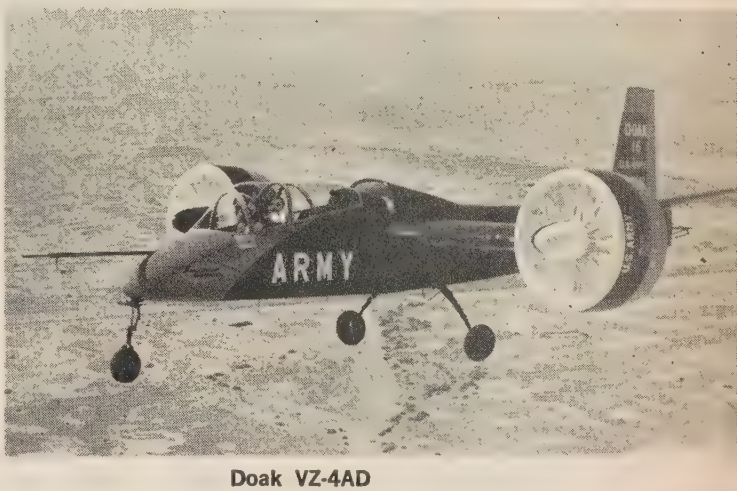
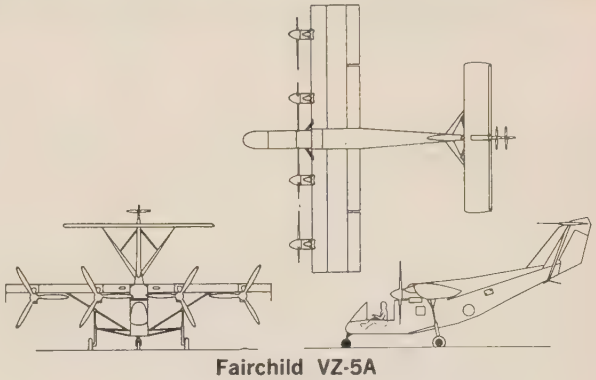
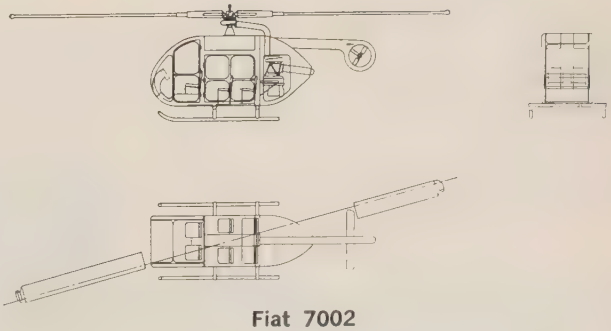



Doak VZ-4AD



Fairchild VZ-5A



Fiat 7002

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We offer the basic tool for analysis of fast reactions, such as plasma jets and rocket exhaust. Model 14 of the Bendix Time-of-Flight Mass Spectrometer combines a high-speed, line-of-sight sample inlet with fast pump-out of the analyzer region so necessary for this difficult analysis. Both plus and minus flame ions can be analyzed as well as neutral radicals and molecules.

**Our engineering department is ready to work with you on solving your specific sample inlet problems, as well as other research and development projects in the missile and rocket field.**

For complete details on this and other applications, plus a copy of The Dow Chemical Company report "Time-of-Flight Mass Spectrometry and Gas-Liquid Partition Chromatography," contact the Cincinnati Division, Dept. X6, 3130 Wasson Rd., Cincinnati 8, Ohio.

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Cincinnati Division
CINCINNATI, OHIO

THE Bendix CORPORATION

Export Sales: Bendix International Division, 205 East 42nd Street, New York 17, New York
Canada: Computing Devices of Canada, Ltd., Box 508, Ottawa 4, Ontario.

Write in No. 23 on Reader Service Card at start of Product Preview Section




diameter, 21 ft 7 in.; tail rotor diameter, 3 ft 5 in.; fuel, 17.42 gal; max speed, about 87 mph; cruise speed, 71 mph; fuel consumption, 2.64 gph (trainer on pivot).

**Borgward Kolibri I**—A three-seat light copter, produced by *Carl F. W. Borgward GmbH, Bremen, West Germany,* the Kolibri has a three-bladed main rotor. The blades are of steel tube spar with plastic bonded plywood covering. The two tail rotors in V-configuration are set at 45-deg angles. Powerplant is a Lycoming VO-435-AIB of 260 hp. The fuselage is an uncovered steel tube structure with tricycle landing gear.

Length overall, 27 ft 3 in.; height, 10 ft; main rotor diameter, 30 ft 10 in.; tail rotor diameter, 5 ft 5½ in.; gross weight, 2645 lb; empty weight, 1765 lb; fuel, 39.6 Imp. gal. Max cruise speed, 100 mph; normal cruise speed, 87 mph; normal range, 260 miles. Service ceiling, 14,760 ft; hovering ceiling (out of ground effect), 1950 ft; SL rate of climb, 195 fpm.

**Bréguet 942**—This "blown wing" STOL new type of transport is designed and built by *S. des Ateliers d'Aviation Louis Bréguet, 24 Rue Georges Bizet, Paris 16, France.* Powerplants are four Turboméca Turmo IIIs or four GE T58s. The cabin seats 50 passengers. The large props are mechanically interconnected for control in case of engine failure. Their slipstream blows over almost the entire wing span. The wing trailing edge has slotted flaps and ailerons. The engines are synchronized to maintain uniform rpm, and the props are synchronized for pitch. No. **108** on Card.

Length overall, 76.6 ft; span, 76.1 ft; height, 31.6 ft; wing loading, 53 psf; gross load, 44,000 lb; useful load, 17,600 lb; fuel, 1930 gal. Normal cruise speed, 215 mph; range, 1000 miles; fuel consumption, 1000 gph; service ceiling, 20,000 ft; SL rate of climb, 1010 fpm; takeoff distance over 50-ft obstacle, 1000 ft.

**Curtiss-Wright VZ-7AP**—A four-rotor aerial platform, the VZ-7AP was designed and developed by *Curtiss-Wright Corp. Santa Barbara Div., Goleta, Calif.,* under an Army Transportation Corps contract. A "flying jeep" type, it has an airframe built up from metal honeycomb into a simple box structure. A Continental Artouste II-B shaft turbine supplies power to the four two-bladed rotors. A rudder in the jet exhaust gives yaw control. It is easily controlled without other stabilizing equipment. The Army requirements called for a low-profile, low-flying platform that can follow ground contours to evade enemy observation and yet climb and fly out of ground effect. Several seats can be installed in tandem. The platform at rear can carry cargo or weapons.

*more on page 69*

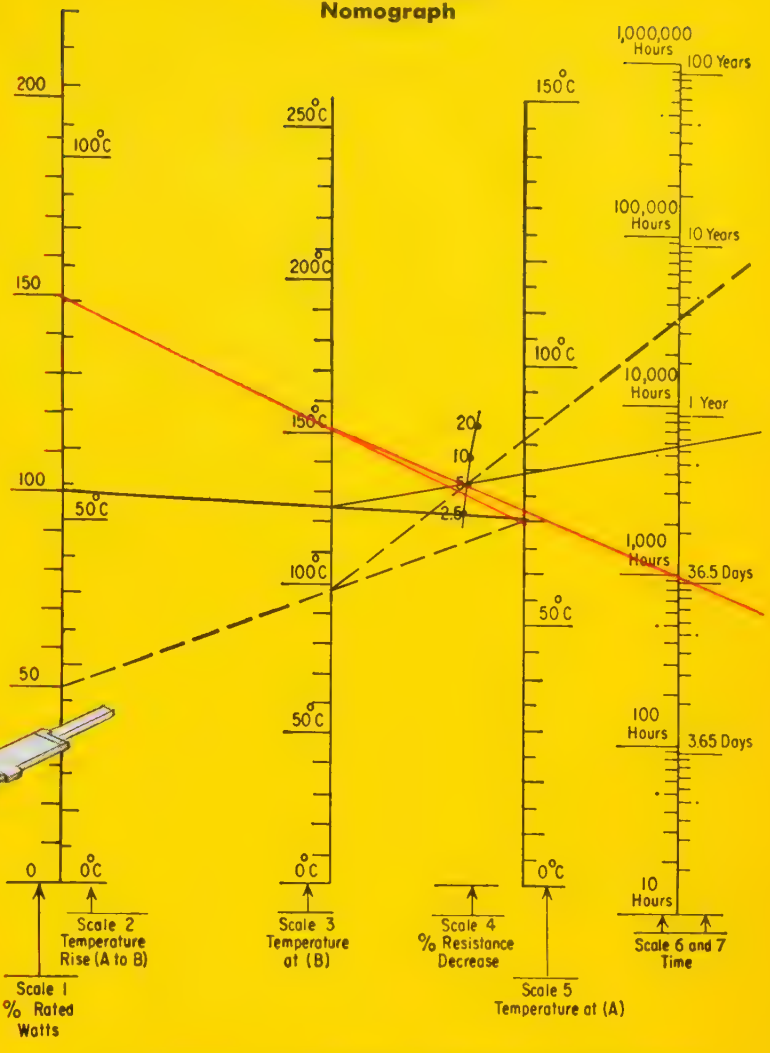


Write in No. 24 on Reader Service Card

# A guide for predicting resistor performance

**NOMOGRAPHS PREDICT LIFE PERFORMANCE OVER LONG PERIODS OF TIME FOR ALLEN-BRADLEY HOT MOLDED COMPOSITION UNITS**

**Type EB (½ Watt) Nomograph**

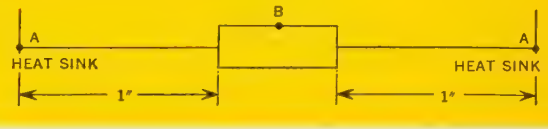



## An Example of Predicting Resistor Performance

Illustration shows use of nomograph to predict the rate of resistance change with life for standard Allen-Bradley resistors. This example is based on a maximum of 5% resistance change with 70°C temperature at points "A" (see drawing below) when operated at

- 50% LOAD
- 100% LOAD
- 150% LOAD

**RESISTOR TEST CONDITIONS**

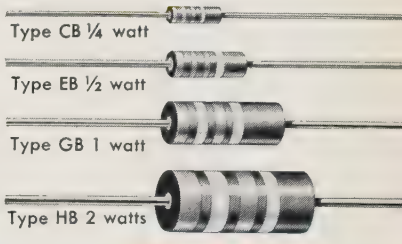



Allen-Bradley's exclusive hot molding process produces resistors with such uniform characteristics that their performance can be predicted with a high degree of certainty. Test data produced in the last 20 years not only in the Allen-Bradley environmental laboratories but also in independent laboratories have been carefully compared and analyzed and have served as a basis for developing the above power nomographs.

And Allen-Bradley has been conservative in projecting test data. Inasmuch as catastrophic failure has yet to occur, the design engineer can develop circuitry with predictable performance.

WRITE TODAY—Power nomographs for standard Allen-Bradley composition resistors are published in Technical Bulletin 5000E. You'll find this information of genuine help and value to you.

**A-B HOT MOLDED COMPOSITION RESISTORS**




ACTUAL SIZE

60-E

# ALLEN-BRADLEY

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

**QUALITY ELECTRONIC COMPONENTS**

# 17 FACTS

about

## ALLEN-BRADLEY

Hot Molded Composition

# RESISTORS

. . . to assist you in the design of more stable, more reliable circuits

Circuit reliability is determined by the quality of the components and the understanding with which they are applied. A-B hot molded resistors are universally recognized for their quality and reliability. Here are 17 facts that will assist you with your design and development work.

1. Resistance changes due to humidity are temporary, but Allen-Bradley resistors can be returned to their original value by proper conditioning or "loading."

2. Resistance changes due to increase in moisture content are always positive.

3. Resistance change due to humidity varies with the resistance value and is less in the lower values.

4. Resistance change which has occurred due to humidity may be returned to the original value by conditioning the resistor at 100°C for 48 hours.

5. Resistors operating at 1/10 rated wattage load are hardly—if at all—affected by humidity.

6. Hermetically sealed resistors do not change because of humidity.

7. Resistance change due to "load life" is permanent and ultimately negative.

8. Resistance change due to "load life" can be minimized—on the order of 1% to 2% in many thousands of hours of service by derating the resistor approximately 50%.

9. This same result can be attained by limiting the maximum operating surface temperature of the resistor under load to 100°C.

10. Resistance change due to soldering is positive; but if the resistor is dry, it will return to its original value in a matter of hours.

11. The temperature characteristic of the Allen-Bradley resistor is positive above and below room temperatures between +10°C and +80°C ambient.

12. The temperature characteristic of the Allen-Bradley resistor is negligible from +10°C to +80°C ambient.

13. The voltage characteristic of the Allen-Bradley resistor is negative. It is less at elevated temperatures than at room ambient (+10°C to +80°C).

14. The voltage characteristic is less in low-value resistors than in high-value units—it is linear.

15. The voltage characteristic and the temperature characteristic tend to cancel one another in an Allen-Bradley resistor under average operating conditions where both voltage and temperature are present.

16. The "heat sink" to which a resistor is connected affects its rating. Resistors operated in parallel should be derated unless an adequate "heat sink" is provided.

17. The quality and reliability of Allen-Bradley resistors are exactly the same regardless of the "tolerances" for which the resistor is listed.

3-60-E

ALLEN-BRADLEY | *Quality* Electronic Component

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, O

## V-STOL SPECS . . .

Length overall, 18.2 ft; width, 9.7 ft (with guard rings off or folded), 16 ft (with guard rings in place); height, 7.6 ft; rotor diameter, 6.5 ft (each); disk loading, 18 psf; gross load, 2400 lb (normal); useful load, 600 lb; fuel, 32 gal; normal speed 45 mph.

**De Havilland of Canada DHC-4 Caribou**—Combining the load-carrying ability of the Otter and Beaver, the Caribou was designed by *The de Havilland Aircraft of Canada Ltd., Downsview, Ont.,* to provide fast troop mobility. The prototype first flew in mid-'58. The rear fuselage is upswept aft of the wing and contains an in-and-out hingeing door that forms the fuselage underside. Powerplant is two P&WA R2000-72s.

Length, 72 ft 6 in.; span, 96 ft; height, 31 ft 8 in.; wing loading, 28.5 psf; gross weight, 26,000 lb; useful load, 8355 lb; fuel, 840 gal. max cruise speed, 182 mph; normal cruise speed (long range), 154 mph; max normal cruise range, 1400 m; max cruise range, 1130 m; fuel consumption: normal cruise—75 gph, max cruise —107 gph; service ceiling: both engines —27,700 ft, one engine—11,900 ft; SL rate of climb: both engines—1575 fpm, one engine—345 fpm; takeoff distance over 50-ft obstacle, 1020 ft; stall speed (power off, gear and flaps down), 60 mph.

**De Havilland of Canada Otter**—This modified Otter STOL transport aircraft is a test vehicle for studying problems of flight well below the power-off stall speed. Landing distance over a 50-ft obstacle is 500 ft. The wing has large flaps. The landing gear was modified from floats to a dolly type for land operations. One P&WA R1340 engine is installed.

Length, 41 ft; span, 58 ft; height, 22 ft; wing loading, 15.9 psf; gross weight, 8000 lb; fuel, 213 gal.

**Doak VZ-4DA**—This tilting ducted-fan design is a research aircraft powered by a Lycoming T53 shaft turbine. *Doak Aircraft Co., Inc., 22309 S. Western Ave., Torrance, Calif.,* designed it conventionally with a welded steel tubing fuselage and molded plastic skin. Wing and tail are all-metal cantilever types. The engine is mounted aft of the tandem seats and powers the ducted propellers mounted on the wing tips. These ducted fans are rotated through 90 deg to function as copter rotors for takeoff. The engine tailpipe has horizontal and vertical vanes hinged at the jet exhaust to aid control during low speed and vertical flight.

Length overall, 33 ft; span, 26 ft; height, 10 ft; wing loading, 33 psf; gross load, 3200 lb; useful load, 800 lb; fuel, 55 gal; max cruise speed, 230 mph; range, 230 m; fuel consumption, 45 gph; service ceiling, 25,000 ft; hovering (out of ground effect), 6000 ft. SL rate of climb, 4000 fpm.

*more on next page*


# Du Pont "Pyrocore," a versatile string-type igniter, gives you uniform firing

**Velocities to 21,000 ft./sec.:** This "string" igniter (available in lengths up to 300 feet) is a flexible tube containing a detonating-ignition composition with which you can ignite a rocket propellant at velocities from 12,000 to 21,000 feet per second, depending upon type and amount of core composition selected.

**"High speed" dependable ignition:** In laboratory tests, "Pyrocore" reduced ignition time 99.5% when compared to a standard primer. Total ignition of a 21½" length of cannon primer was achieved in less than ¼ millisecond, as against 50 milliseconds required with a squib primer.

The stringlike form of "Pyrocore" gives you new freedom in design of rocket motors. For example, you can thread "Pyrocore" through jelly roll or basket type igniter assemblies, or string it around the propellant grains.

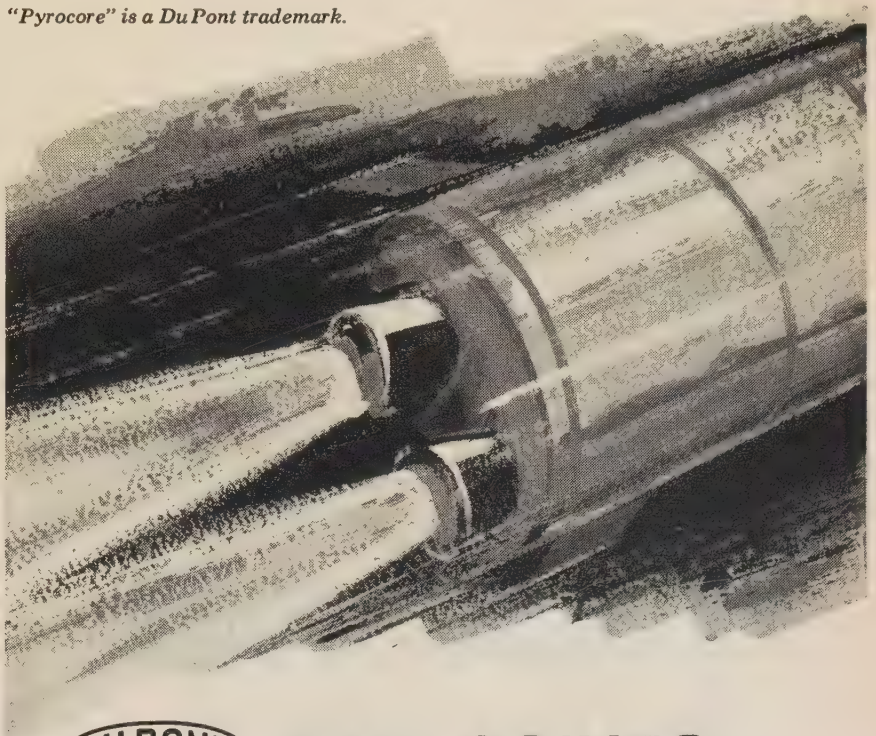
The versatility you obtain with "Pyrocore" results in the controlled simultaneous ignition of large surface areas of even relatively inert propellant grains.

Initiator assemblies may be located outside the propellant chamber, eliminating a major source of residue in the reaction zone. The "Pyrocore" itself detonates cleanly, leaves very little residue.

**SAMPLE KIT AVAILABLE**

"Pyrocore" igniter sample kit containing most standard types of "Pyrocore," and various end primers, initiators and accessories is available. Description and price of this kit will be sent if you write Du Pont, Explosives Department, 6539 Nemours Building, Wilmington 98, Delaware.

*"Pyrocore" is a Du Pont trademark.*



DU PONT EXPLOSIVES

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

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★ *Positive Mechanically Locked Stem*
★ *Flush Fracture (No Stem Trimming)*
★ *Strong Clinch*
★ *Wide Grip Range*
★ *Positive Hole Fill*

The Cherrylock* "2000" Series Locked Stem Rivet offers every feature desired in an aircraft blind rivet . . . proven high sheet clamp-up with no stem trimming (fractures flush on installation), uniform head seating, complete hole-fill, wide grip range, and positive mechanically locked stem.

Fast, economical, easy installation (with no stem trimming) is available with Cherrylock rivets, using existing Cherry installation guns. You get better fastening at lower installed cost.

One rivet can be used for several material thicknesses, reducing stock requirements and lowering costs. Positive hole-fill, even in oversized holes, simplifies preparation problems to further reduce installation costs. Available in:

**A-286 Stainless Steel—Monel—Aluminum**

For technical data on the new Cherrylock "2000" Series rivets, write Townsend Company, Cherry Rivet Division, Box 2157-P, Santa Ana, California.

**Patent Pending*

**CHERRY RIVET DIVISION**
SANTA ANA, CALIFORNIA
**Townsend Company**
ESTABLISHED 1816 • NEW BRIGHTON, PA.

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Ganonoque, Ontario
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**Doman LZ-10**—A general-purpose copter, the LZ-10 features "accordion" doors for through-loading, a sealed rotor system, no grease fittings, and no post-flight maintenance. The rotor system is a non-articulated, tilting type. Powered by a Lycoming GSO-720, the LZ-10 is produced by *Doman Helicopters, Inc., Danbury, Conn.* No. **109** on Card.

Length overall, 38 ft; height, 10 ft 4 in.; main rotor diameter, 48 ft; gross load, 5500 lb; useful load, 2250 lb; fuel, 76 gal (main tank), 119 gal (main and auxiliary tanks); max cruise speed, 115 mph; normal cruise speed, 90 mph; max cruise range (with 45-min reserve), 265 miles; normal cruise range, 390 miles, fuel consumption (@5500 lb), 31 gph; service ceiling, 24,000 ft; hovering ceiling (in ground effect), 10,500 ft; SL rate of climb, 1150 fpm.

**Dornier DO-29**—First flown in December 1958, the DO-29 is a government-supported V-STOL research aircraft developed by *Dornier Werke GmbH, Neu-Aubing, Bavaria, West Germany*. A twin-pusher-engine type, it is used to study V-STOL problems and test powerplant installations. The engines now installed are two Lycoming GO-480s. The airplane is a greatly modified DO-27, more than 400 of which have been ordered by the West German air force. The cockpit has a Martin-Baker ejection seat.

Wing span, 43 ft 4 in.; wing area, 234 sq ft; wing loading, 22.5 psf; gross load, 5280 lb.

**Fairchild VZ-5FA**—An experimental VTOL vehicle, by *Fairchild Engine & Aircraft Corp., Hagerstown, Md.*, the VZ-5FA is based on the "blown flap," or vectored-slipstream, technique and uses large, full-span trailing edge flaps. It is powered by a GE YT58-GE-2 shaft turbine driving four props mounted on the wing leading edge. The props blow over a NASA sliding forward flap and a slotted aft flap. To aid control in vertical and low speed flight, a small rotor on the tail assembly is used. Takeoff distance is zero.

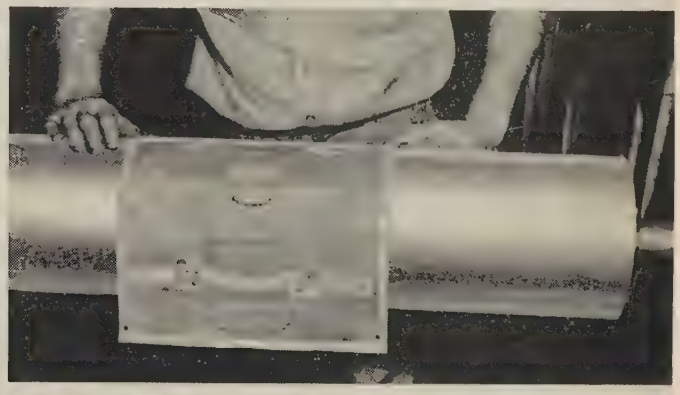
Length overall, 33 ft 8 in.; span, 32 ft 9 in.; height, 16 ft 10 in.; prop diameter, 101 in.; tail rotor diameter, 33 in.; wing loading, 20.86 psf; gross load, 3976 lb; useful load, 594 lb; fuel, 43.5 gal. max speed (structurally limited), 160 mph. stall speed, 0.

**Fiat 7002**—A copter carrying a pilot and six passengers, the Fiat 7002 is a two-blade, dual-control type. Jets of compressed air on the blade tips operate the main rotor. Since no fuel is burned in the operating compressed air, this "cold jet" offers the advantages, according to *Fiat, 200 Corso Giovanni Agnelli, Turin, Italy*, of the lowest value of empty weight per pound of payload, simplest construction (no mechanical units like clutches, reduction gears, drive shafts), lowest

**more on page 73**

# HOLD IT!

## . . . with a powerful Polyken 2-face tape



## Airliners, flexography, window display, what have you . . . Polyken bonds two surfaces hard and fast

Bringing two surfaces together in a semipermanent bond is a simple low-cost job when you trust Polyken's double-faced tape—one of the most versatile tapes you can buy.

It has the highest holding power, users report, of any double-faced tape. Yet it can be neatly removed at any time. Airlines, as the left-hand photo shows, rely on Polyken to economically secure cabin carpets—for neatness and passenger safety.

### So strong it holds rotary printing plates

Flexographers, as shown in the photo at upper right, count heavily on Polyken to keep plates from shifting or distorting. For such a chore, the wide variety of widths offered by Polyken comes in quite handy. Even window dressers, lower right photo, depend on this tape for solutions to a variety of problems.

If you have any problems that resemble these—however remotely—contact your Polyken representative.

Find Your Nearest Distributor In The 'Yellow Pages'

**Polyken®**

**INDUSTRIAL TAPES**

THE KENDALL COMPANY
Polyken Sales Division

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**Immersion Ultrasonic Testing** is the latest addition to Standard's family of extensive quality-control facilities. Specially designed for Standard and one of the first of its kind installed by a specialty steel maker, this new facility is used to detect minute flaws in extremely high quality thin-section and complex-section steel shapes.

It is essential to test for internal flaws in such vital jet and missile engine parts as expander rings, motor case rings, turbine discs, and compressor wheels. Bring your next difficult alloy problem to us—you'll appreciate our personalized service as well as our superior quality control. Write for free illustrated booklet, "Quality Control at Standard."

# Standard Steel Works Division

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BALDWIN BLH LIMA-HAMILTON

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S-N SPEED INCREASER GEAR units are adaptable to aviation test equipment or industrial use, offer a wide variety of gear ratios and output speeds. For special applications, S-N engineers will design and build to your specifications. Whether you need one unit or many, rely on S-N high speed experience for complete satisfaction.

**STANDARD UNIT SPECIFICATIONS**

| SERIES 4000 | SERIES 4030 |
|---|---|
| **Capacity:** Up to 50 HP | **Capacity:** Up to 200 HP |
| **Gearing:** Helical, single stage | **Gearing:** Double helical, single stage |
| **Output speed:** to 30,000 RPM | **Output speed:** to 12,000 RPM |
| **Ratios:** 1:1.03 to 1:5.50 | **Ratios:** 1:2.00 to 1:6.58 |
| **Output drive:** Single | **Output drive:** Single or dual |

All units may be supplied with stub shaft or aviation accessory drives as standard equipment.

For complete information write to:

**SNOW-NABSTEDT**
*Transmission Engineers*
FOR HALF A CENTURY
"MAKERS OF JOE'S GEARS"
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cost, highest reliability, longest operating life between overhauls, lowest maintenance cost, and lowest operating cost. Powerplant is a Fiat 4700 turbo-generator. Air compressor and engine are mechanically independent. A small, ducted tail rotor is mechanically driven by the main rotor. No. **110** on Card.

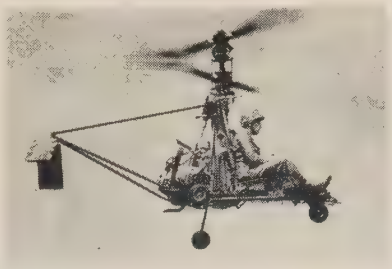
Length overall, 20 ft 1 in.; height, 9 ft 5½ in.; main rotor diameter, 39 ft 4 in.; gross load, 3087 lb; useful load, 1764 lb; fuel, 525; normal cruise speed, 84 mph; range, 186 miles; service ceiling, 11,155 ft.

**Goodyear XAO2(G) Inflatoplane**—Wing and tail assemblies as well as the air frame are made of inflatable, rubberized Airmatfabric. Designed by *Goodyear Aircraft Corp., Akron 15, Ohio,* the plane is powered by a McCulloch 4318E. It can be inflated either by manual pump or compressed air bottle. Pressure is seven psi.

Length overall, 19.2 ft; span, 28 ft; height, 7 ft 2 in.; wing loading, 5 psf; gross load, 742 lb; useful load, 450 lb; fuel, 18 gal; max cruise speed, 60 mph; normal cruise speed, 55 mph; max range, 275 miles; fuel consumption, 3.6 gph; SL rate of climb, 500 fpm; takeoff distance over 50-ft obstacle, 645 ft; stall speed (power off, gear and flaps down), 43 mph.

**Gyrodyne DSN-1**—A remotely controlled coaxial copter designed by *Gyrodyne Co. of America, St. James, N. Y.,* to carry a homing torpedo launched from a destroyer. It forms the airborne portion of the Dash weapon system for anti-sub warfare.

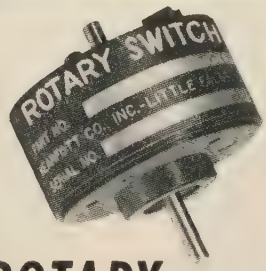
**Gyrodyne YRON-1 Rotorcycle** — There are four versions of this one-man copter equipped with a coaxial rotor system. The first two have 17-ft-diameter rotors, the third has a 20-ft-diameter rotor, and the fourth, a 15-ft-diameter rotor. This last, ultra-light version is powered by a Solar T62 engine rated at 62 hp (standard day). Expected minimum life between major overhauls is 500-1000 hours, Version I is powered by a four-cycle Porsche engine with a SL takeoff rating of 62 hp (net after cooling). Version II is powered by a T62; Version III by a Porsche rated at 72 hp. Expected minimum life between major overhauls is 1000 hours. A twin-engine version with a 20-ft diameter rotor is being developed. No. **111** on Card.



Version I: Length overall, 11 ft 5 in.; height, 8 ft; rotor diameter, 17 ft; disk loading, 3.1 psf; gross load, 700 lb; useful load, 270 lb; fuel, 5 gal; max cruise

*more on page 75*


**BASIC BUILDING BLOCKS FROM KEARFOTT**




## ROTARY SWITCH

Kearfott's rotary switching devices for missile and aircraft systems are used to sequence or switch circuitry as a function of time or shaft position. Used in conjunction with sensitive relays or solid state switching techniques, high current loads can be handled. These switches consist primarily of shaft assembly and bearing mounted cylinder divided into conducting and non-conducting segments with continuous track for common input. Multiple conductor "broom" type brushes ride on each cylinder track while number of tracks and segmentation of each is function of the number of circuits and type of "on-off" sequencing required.

**TYPICAL CHARACTERISTICS P1280-11A**

Number of switching tracks: 2

Angular Segmentation (both referenced to 0° start):
Track 1 — Non-conducting about 0° + 50°
Track 2—Conducting 0° -180°
Non-conducting 180° -0°

Mechanical Accuracy of Segmentation:
±1° (better as required)

Starting and Running Torque:
0.1 oz.-in.

Current Capacity:
50 ma at 28V/Brush (suitable for any sensitive relay or solid state switching circuits)

*Write for complete data.*

**KEARFOTT DIVISION**
**GENERAL PRECISION, INC.**
*Little Falls, New Jersey*

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# SPECIALISTS IN THE 3 C's OF ELECTRONICS

## CABLES

**Complete** versatility of design plus extra reliability characterize Bendix® Cable Assemblies. Types include encapsulated or braided missile control cable, thermocouple harness, fuel cell, ground cabling, high temperature, and flat conductor cable.

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**Count** on Bendix High Temperature Capacitors for premium performance on missile and high-speed aircraft applications. Proved operation from −55°C. to +400°C. with no voltage derating and low capacitance variation.

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**Can** you use the finest electrical connectors in the business? Then try ours. Wide range of sizes and types available, including Pygmy® Miniature, Rack and Panel, QWL, and MS-R, and connectors for special applications.

*For fast service on Cables, Capacitors, and Connectors, contact:*

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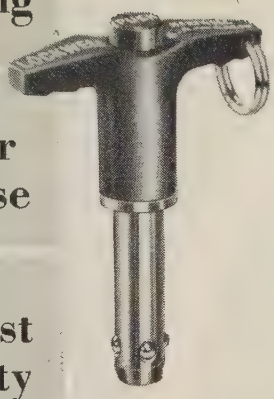
better holding
+
easier release
+
highest quality
=greater reliability



LOCKWELL*
*quick release pins*

Exclusive design features in this Hartwell development make these Lockwell Pins superior for *your* application.

Lockwell Pins are built with an exclusive 4-ball locking element for superior tension properties . . . with fail-safe design assuring permanent operation . . . with handles that provide greatest non-slip clearance . . . and with RED release button for quick identification.

**SPECIAL DESIGN**—In addition to standard configurations, Lockwell features can be incorporated into pins to meet special design requirements. Your inquiry is sincerely invited.

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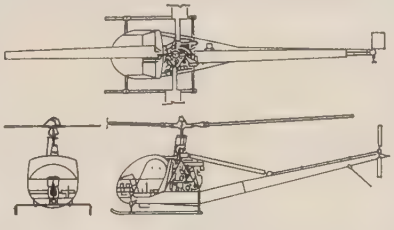
speed, 68 mph; normal cruise speed, 65 mph; max range (30 lb of fuel), 59 miles; fuel consumption; max cruise—5.2 mph, normal cruise—5 gph; service ceiling, 7200 ft; hovering ceiling: in ground effect—4900 ft; out of ground effect—2400 ft; SL rate of climb (gross weight) 410 fpm.

Version II: same dimensions as I; disk loading, 2.6 psf; gross load, 605 lb; useful load, 280 lb; fuel, 5 gal; max cruise speed, 72 mph; normal cruise speed, 72 mph; max range, 31 m; fuel consumption, 12 gph; SL rate of climb, 1100 ft.

Version III: length overall, 11 ft 6 in.; height, 9 ft; rotor diameter, 20 ft; disk loading, 2.9 psf; gross load, 910; useful load, 374 lb; fuel, 5 gal; max cruise speed, 77 mph; normal cruise speed, 64 mph; max range, 54 miles; fuel consumption: max cruise speed—6.5 gph, normal cruise speed—5.3 gph; service ceiling, 13,800 ft; hovering ceiling: in ground effect—5300 ft, out of ground effect—2800 ft; SL rate of climb, 480 fpm.

Version IV: length, 11 ft 5 in.; height, 7 ft 6 in.; main rotor, 15 ft; disk loading, 3 psf; gross load, 530 lb; useful load, 230 lb; fuel, 5 gal; max cruise speed, 74 mph; normal cruise speed, 74 mph; range, 28 miles; fuel consumption, 12 gph; SL rate of climb, 1840 fpm.

**Hiller H-23D Raven**—This Army copter is a three-place vehicle for primary training that is also used for observation, liaison, supply, recon, rescue, etc. Powered by a 250-hp Lycoming VO-435, it was the first military copter to fly 1000 hours without removal or overhaul of any major component, says *Hiller Aircraft Corp., 1350 Willow Rd., Palo Alto, Calif.* The "D" version has a completely new transmission and drive system. The transmission reduced the weight by 20 per cent and increased the horsepower capacity by 40 per cent. The new tail rotor and drive system includes simpler drive shaft couplings, a revised gear box, and a tail rotor equipped with zero-offset flapping hinges and installed to the length of the tail boom to reduce buzz and vibration.

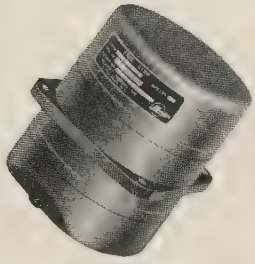


Length overall, 27.8 ft; height, 9.8 ft; main rotor diameter, 35.4 ft; tail rotor diameter 5.5 ft; gross weight, 2700 lb; useful load, 1000 lb; fuel, 46 gal (standard); max cruise speed, 95 mph; normal cruise speed, 82 mph; max range (45-min reserve), 200 miles; range at max cruise speed, 165 miles; fuel consumption, 14 gph; service ceiling, 13,200 ft; hovering ceiling: in ground effect—5200 ft, out of ground effect—1250 ft; SL rate of climb, 1050 fpm.

**Hiller X-18**—An experimental V-

*more on page 77*

BASIC BUILDING BLOCKS FROM KEARFOTT



FREE GYRO

A highly reliable, two-degree-of-freedom instrument utilizing AC synchro transmitters at each gimbal axis. Designed to operate under the most severe missile conditions, this gyro has AC torquers mounted at each gimbal axis to permit command positioning or slaving of spin axis to desired reference position; each torquer capable of producing a precession rate of 360°/minute with 12.5 watts/phase power input.

TYPICAL CHARACTERISTICS #Q2315

Environmental Capabilities
Temperature Range:
(operative): —54°C to +71°C
(non-operative): —65°C to +85°C
Altitude: Unlimited
Vibration: 10g, 10-2000cps

Pickoffs
Excitation:
26V, 400 cps, single phase
Output (sinusoidal):
11.8V ± 5% max.
Error from E.Z.: 10 min. max.

Motor
Excitation:
115V, 400 cps, three phase
Speed: 23,500 RPM
Momentum:
2.25 x $10^6$ gm $cm^2$/sec.

Caging and Preset Provision
(Electrically energized torquer type)
Excitation: 115V max./phase
Torquer Constant:
22.8 dyne cm/$Volt^2$

Performance Characteristics
Free Drift:
5°/minute each axis
Runup Time:
1 minute max.
Torquing Rate:
360°/min. (intermittent)
40°/min. (continuous)

*Write for complete data.*

KEARFOTT DIVISION
GENERAL PRECISION, INC.
*Little Falls, New Jersey*

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# Reaching for the moon?

## Alcoa goes to work immediately on defense projects

Lunar, interplanetary or orbital project—Alcoa is pre-eminently qualified to be part of it. No other light-metals company has more experience. Or has invested more money or man-hours in research. Or has more modern equipment, in more plants—more savvy in developing and manufacturing new aluminum alloys. Alcoa's research and development facilities are integrated with its nationwide manufacturing complex. Regardless of how many operations are involved, each project is produced by one, individual, over-all effort. For more information, write: Aluminum Company of America, 2027-F Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

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## PRECISION PARTS FOR AIRCRAFT AND MISSILES

For many years Fenn has been entrusted to produce vital and complex components in large quantities for aircraft. Today, Fenn has the facilities and personnel experienced in machining of special metals and alloys required in the aircraft, missile, and nuclear fields. Fenn's ultra-modern plant includes the finest metal working machines, heat treating, plating, surface treatment, a metallurgical laboratory, and resident air force inspection. We welcome the opportunity to discuss your requirements. Write for copy of *Fenn Facilities*.

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THE FENN MANUFACTURING COMPANY

Newington, Conn. Phone: MOhawk 6-2471

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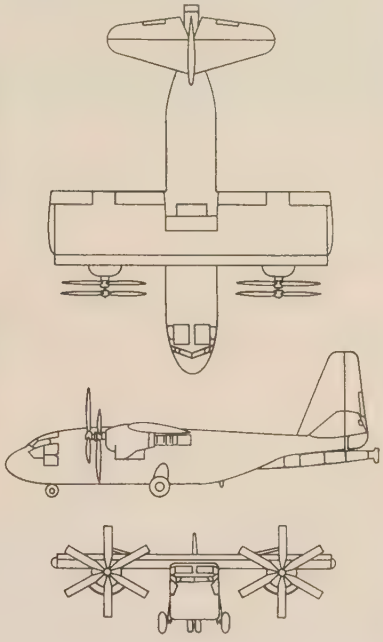
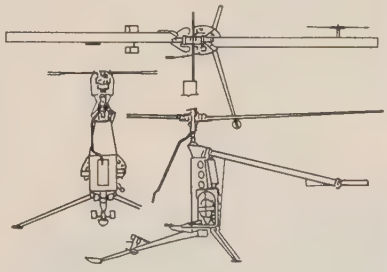
## V-STOL SPECS . .

STOL vehicle was designed around the Chase YC-122 transport. With a top speed limited by the structure to 300 mph, it is the largest of the higher speed VTOLs in the U.S. The high wing pivots through 90 deg for vertical takeoff. Two Allison T40-A14 turboprops drive C-W 16-ft six-bladed contraprops. Mounted in the rear fuselage is a Westinghouse J34 jet engine with an extended tailpipe and a jet diverter, which is used for pitch control in vertical flight. USAF's contract for the X-14 called for a twin-engine tilting-wing convertiplane that can take off and land vertically as well as operate as a fixed-wing transport and have high forward speed.



Length overall, 63 ft; span, 48 ft; height, 24 ft; gross weight, 33,000 lb; speed, 250-300 mph.

**Hiller YROE-1 Rotorcycle**—This one-man copter can be folded into a small package for easy transport or parachute drop. Only a few minutes are needed to assemble and fly the machine from the completely folded state. Built for the Marines, the



YROE-1 is being developed for small tactical maneuvers, observation and liaison. Powerplant is a Nelson H-63B engine of 43 hp. There is a two-bladed main rotor mounted on a shaft and a two-bladed anti-torque tail rotor. Metal blades are used in both rotors.

*more on next page*


## BASIC BUILDING BLOCKS FROM KEARFOTT

## SIZE 11 SYNCHRONOUS MOTOR

Featuring pull out torque efficiency of 50% nominal with 3.4 watts input and 3 watts pull out power, this synchronous motor represents a major achievement in terms of performance for a unit of this extremely small size. Additional advantages made possible by Kearfott's unique design include resistance to environmental extremes, light weight construction and low unit cost. This motor and its variations are available in production quantities.

**TYPICAL CHARACTERISTICS R172**

| | | |
|---|---|---|
| Excitation: | Phase 1 | Phase 2 |
| Voltage | 40V | 40V |
| Frequency | 400 CPS | 400 CPS |
| Power | 2.3 Watts | 2.3 Watts |
| Current | 0.157 Amps | 0.157 Amps |

Performance:

| | |
|---|---|
| Synchronous Speed | 8000 RPM |
| Stall Torque | 0.2 In. Oz. |
| Pull Out Torque | 0.35 In. Oz. |
| Pull In Torque | 0.15 In. Oz. |

*Write for complete data.*

KEARFOTT DIVISION
GENERAL PRECISION, INC.

*Little Falls, New Jersey*

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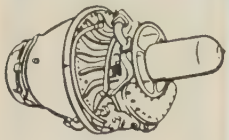
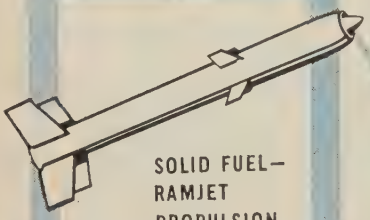
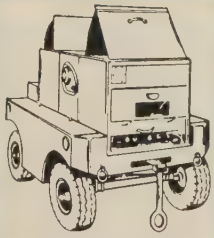


TURBINE PROPULSION



SOLID FUEL—
RAMJET
PROPULSION



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- Development
- Production

● Continental Aviation & Engineering Corp. is exceptionally well qualified, both by experience and by facilities, for work on the weapons systems of tomorrow. Our background embraces not only a half-century of internal combustion engine experience, but also years of pioneering in gas turbine engine development, and more than a decade in the field of solid fuels for ramjet propulsion of missiles and target drones . . . Continental is staffed and equipped for a wide range of assignments, military and commercial. The Detroit Division Research and Development Department is supported by our modern-to-the-minute Component Testing Laboratory complete with environmental facilities located at Toledo. The Toledo Production Division now producing various turbine engines in volume is capable of supporting diversified programs . . . The CAE record of achievement is one of which many a larger company might be proud. Inquiries are invited from those having propulsion problems, on the ground, on the water, in the air.

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SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

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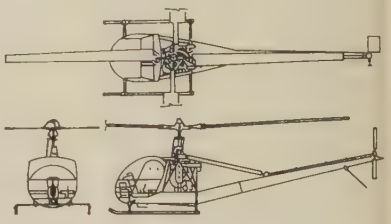
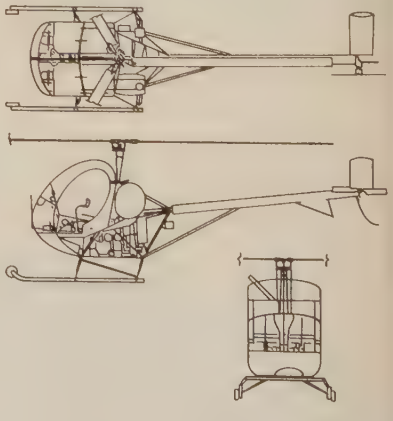
Length overall, 11.5 ft; height, 7 ft; main rotor diameter, 18.5 ft; gross weight, 556 lb; useful load, 256 lb; fuel, 2½ gal; max cruise speed, 70 mph; normal cruise speed, 52 mph; service ceiling, 13,200 ft; hovering ceiling: in ground effect—9200 ft, out of ground effect—5500 ft; SL rate of climb, 1160 fpm.

**Hiller 12E-4**—Hiller's first four-place copter can be obtained as a kit mod to the standard 12E. Production models will fly this year. Powered by a Lycoming VO-540 with power kit. No. **112** on Card.



Length overall, 30 ft; ht, 9.8 ft; main rotor diameter 35.4 ft; tail rotor diameter, 5.5 ft; gross weight, 2760 lb; useful load, 1040 lb; fuel, 46 gal (standard); max cruise speed, 96 mph; normal cruise speed, 87 mph; range, (with 45-min reserve) at normal cruise speed—215 miles; at max cruise speed—176 miles; fuel consumption: at max cruise speed—17 gph, at normal cruise speed—14 gph; service ceiling, 16,500 ft; hovering ceiling: in ground effect—11,050 ft, out of ground effect—7300 ft; SL rate of climb, 1340 fpm.

**Hughes 269A**—This ultra-light helicopter brings the direct operating cost down to $10.65 per hour, according to *Hughes Tool Co., Aircraft Div., Culver City, Calif.* The basic vehicle, including doors and built-in vents, costs $22,500 (as of Jan. 15, 1960). With very little vibration or noise, it is useful in photographic traffic control, and observation work. A third seat can be installed aft of the cabin. Powerplant is a Lycoming 0-360-C2B.



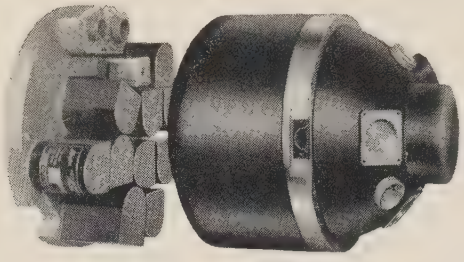
The main rotor has three fully articulated blades of metal. A V-belt drive system eliminates the need for a clutch. The Tail rotor is a two-bladed teetering type shaft-driven from the V-belt. Fuselage is a built-up steel

*more on page 80*

# **KEARFOTT** is developing

# the Subroc

# guidance system.



***Engineers:*** *Kearfott offers challenging opportunities in advanced component and system development*

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LITTLE FALLS, NEW JERSEY

**GENERAL PRECISION INC.**
OTHER DIVISIONS OF GENERAL PRECISION INC.—GPL-LIBRASCOPE-LINK

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# Here's what they've done with this remarkable READALL® instrument

Several weeks ago, we used the ad you see in the picture to ask a question and give some facts. We said that the READALL readout instrument was about the size of a candy bar, and that it could display, store or transfer up to 64 different numbers, letters or symbols *without* using complicated conversion equipment and "black boxes."

We explained that the READALL instrument was originally developed for data display in flight control equipment. We described the READALL instrument as an electro-mechanical, D.C. operated, readout device for displaying characters in accordance with a pre-determined binary code . . . a compact self-contained device . . . which can be applied to the output of digital computers, teletype receiving equipment, telemetering systems, or wherever data must be displayed. And we wound up by asking about new applications for our READALL instrument. Here are some of the answers to our question:

**1.** A leading aircraft corporation is using READALL instruments in a visual intercom system in patrol aircraft that's connected with anti-submarine warfare.

**2.** Another company uses READALL instruments in ground checkout equipment for a new Air Force bomber.

**3.** An oil company uses these readout instruments in a data reduction system that converts magnetic tape seismographic data to printed digital data and graphic chart strips.

**4.** A missile manufacturer uses READALL instruments in an automated "Missile Skin" milling machine.

**5.** These readout devices are being applied in nuclear reactor work for remote control and indication of rod position.

**6.** READALL instruments are now used in an electric power station monitoring system in Philadelphia.

**7.** READALL instruments are being used in display boards for the Air Defense Headquarters.

**8.** Another aircraft manufacturer uses READALL instruments in a flight simulator.

**9.** A branch of the military designed the READALL instruments into an airborne bomb-direction computer.

**10.** An aircraft systems manufacturer uses READALL instruments for display and print-out of data with a computer in a high altitude weather reconnaissance project.

We would be happy to tell you more about the READALL and its applications.

We would be happy to hear from you about possible applications. Please write to us at the address below.

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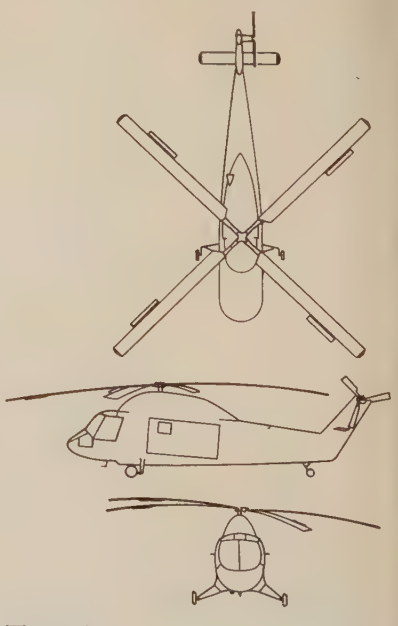
tube structure with single-piece aluminum-tube tail boom. No. **109** on Card.

Length overall, 22.2 ft; height, 8 ft; main rotor diameter, 25 ft; tail rotor diameter, 3.3 ft; gross weight, 1550 lb; useful load, 683 lb; fuel, 25 gal; max cruise speed 85 mph; normal cruise speed, 75 mph; range: max (45-min reserve)—220 miles, 85 mph—170 miles; fuel consumption: normal—10 gph, max cruise speed—12 gph; service ceiling, 17,000 ft; hover ceiling: in ground effect—13,500 ft, out of ground effect—11,500 ft; SL rate of climb, 2500 fpm.

**Kaman H-43B Huskie**—A crash rescue copter designed by *The Kaman Aircraft Corp., Bloomfield, Conn.,* and powered by a Lycoming T53 shaft turbine. The rear cabin has clamshell doors. The twin rudders on the raised tail unit are controlled by an autostabilizer. Two flexible, interconnected fuel tanks are installed under the cabin floor. There is also provision for auxiliary tanks. Passenger capacity is 8-12.

Length overall, 25 ft 2 in.; height, 12 ft 7 in.; main rotor diameter, 47 ft; gross weight, 5870 lb; useful load, 1592 lb; fuel, 198 gal (normal); max cruise speed (SL), 104 knots; range (45-min reserve), 183.5 miles; fuel consumption, 430 gph; service ceiling, 25,700 ft; hovering ceiling: in ground effect—20,100 ft, out of ground effect—16,600 ft; SL rate of climb, 2000 fpm.

**Kaman HU2K1 Seasprite**—Flown last year, the Navy HU2K1 was designed for rescue, flying-crane operation passenger transport, observation and recon, casualty evacuation, etc., under all weather conditions. It departs from the usual Kaman design in having a three-bladed tail rotor.



The main rotor is four-bladed. Powerplant is a GE T58. The fuselage is of all-metal semi-monocoque construction. Retractable main wheels and a fixed tail wheel are provided.

Length overall, 52 ft 2 in.; height, 12

***more on page 82***

# Who put the cart before the horsepower?

*Autonetics did.* Autonetics foresaw that the electronic systems inside a modern weapon would become as important as the frame that enclosed them... foresaw that the twin bugaboos would be time and talent: the time it would take a swarm of skilled technicians with meters and hand probes to make a thorough maintenance test—and the scarcity of such technicians. That's why Autonetics, together with the Department of Defense, set out to automate the whole procedure.

*Result:* carts that contain today's most versatile automatic checkout systems. These systems match the needs of the majority of manned and unmanned weapon systems. Adaptive equipment for testing special electronic systems can be packaged in similar carts and plugged into the basic cart. The system is thus complete and readily mobile.

*Here's the payoff:* as part of the Naval Avionics Support System, these new automatic checkout centrals will do the job 100 times as well—and with infinitely greater accuracy. All the operator needs to know is which button to push. This is the reliable way to find fault before you fly.

Automatic checkout centrals by **Autonetics**

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Look to Eastern Industries for the advanced pressurization/dehydration packs required by the avionic and ground support systems of tomorrow. Whenever a precisely controlled flow of dehydrated air is required, Eastern design and production experience team up to create compact, lightweight, reliable subsystems. Characteristics and performance range of existing units:

Characteristics and performance range of existing units:

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weights: from 8 lbs. to 115 lbs. complete

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Eastern AVIATION PRODUCTS

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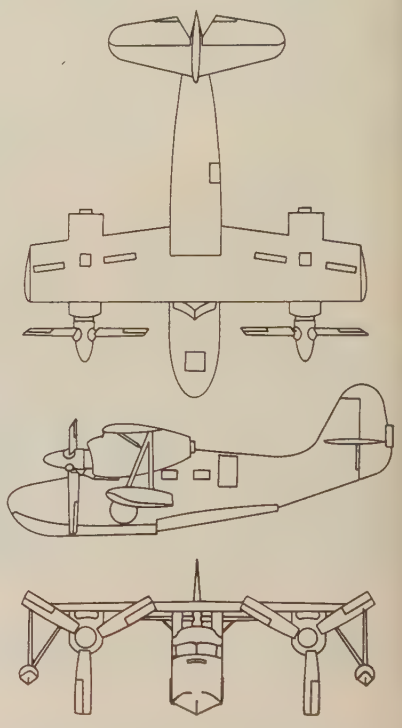
## V-STOL SPECS . . .

ft 5 in.; main rotor diameter, 44 ft; tail rotor diameter, 8 ft; gross weight, 7378 lb; useful load, 2326 lb; fuel, 276 ga'

**Kaman K16B**—Soon to enter its flight test program, the K16B is a V-STOL flying boat using two prop-rotors mounted on a tilting wing and powered by two GE T58-2A gas turbines rated at 875 hp normal and 1024 hq military. The prop-rotors have small control flaps on the trailing edge of each blade. Conventional controls in the cockpit are connected to these flaps so that the prop-rotors control the aircraft somewhat like copter rotors during hovering and at speeds up to 50 mph. Above 50 mph, the conventional controls are used. Vertical lift is obtained by the combination of the prop-rotors and Fowler flaps. Speed ranges from zero to 300 mph.



Length overall, 38 ft 4 in.; span, 34 ft; height, 20 ft 7 in.; prop-rotor diameter, 15 ft 2 in.; gross weight, 9000 lb; max design speed, 300 mph. Wing-flap area, 302 sq ft; horizontal tail area, 76 sq ft; vertical tail area, 48 sq ft; spoiler area (projected max half span), 5 sq ft.

**Kellett ASP**—Used to study problems of an "airborne support platform" (ASP) for the Army. Kellett was authorized either to design a new type of platform or to modify an "aerial jeep" so that pitching at increased forward speeds would be eliminated. The present "jeep" designed by *Kellett Aircraft Corp., Willow Grove, Pa.,* is a copter type supported by two horizontal, three-bladed rotor-props (fore and aft) and equipped with ducts to provide thrust. Because tests showed that the "jeep" at increased forward speeds

more on page 84

# Here's the one fan that meets all of today's electronic cooling requirements!

. . . compare it with the weight of your lighter

## ENGINEERS WHO THINK AHEAD...

## CHOOSE **MINI-SPOT** BY PESCO!

Developed by forward-looking Pesco engineers to meet advanced cooling requirements, Mini-Spot Axial Flow Fans are available from stock in limited quantities for evaluation or prototype development. These lightweight miniaturized fans provide selective cooling in confined areas . . . meet and exceed all applicable military specifications for shock, humidity, vibration, temperature! A self-contained package with micro-matched fan and motor produced by Pesco, Mini-Spot fans are now extensively employed in weapon systems guidance, communications and ground support equipment as well as marine and widely diversified commercial electronics applications. In addition to standard axial flow fan designs with ratings from 5 to 45,000 cfm, Pesco offers a complete design-and-build service to meet your specific requirements. Write for complete information.

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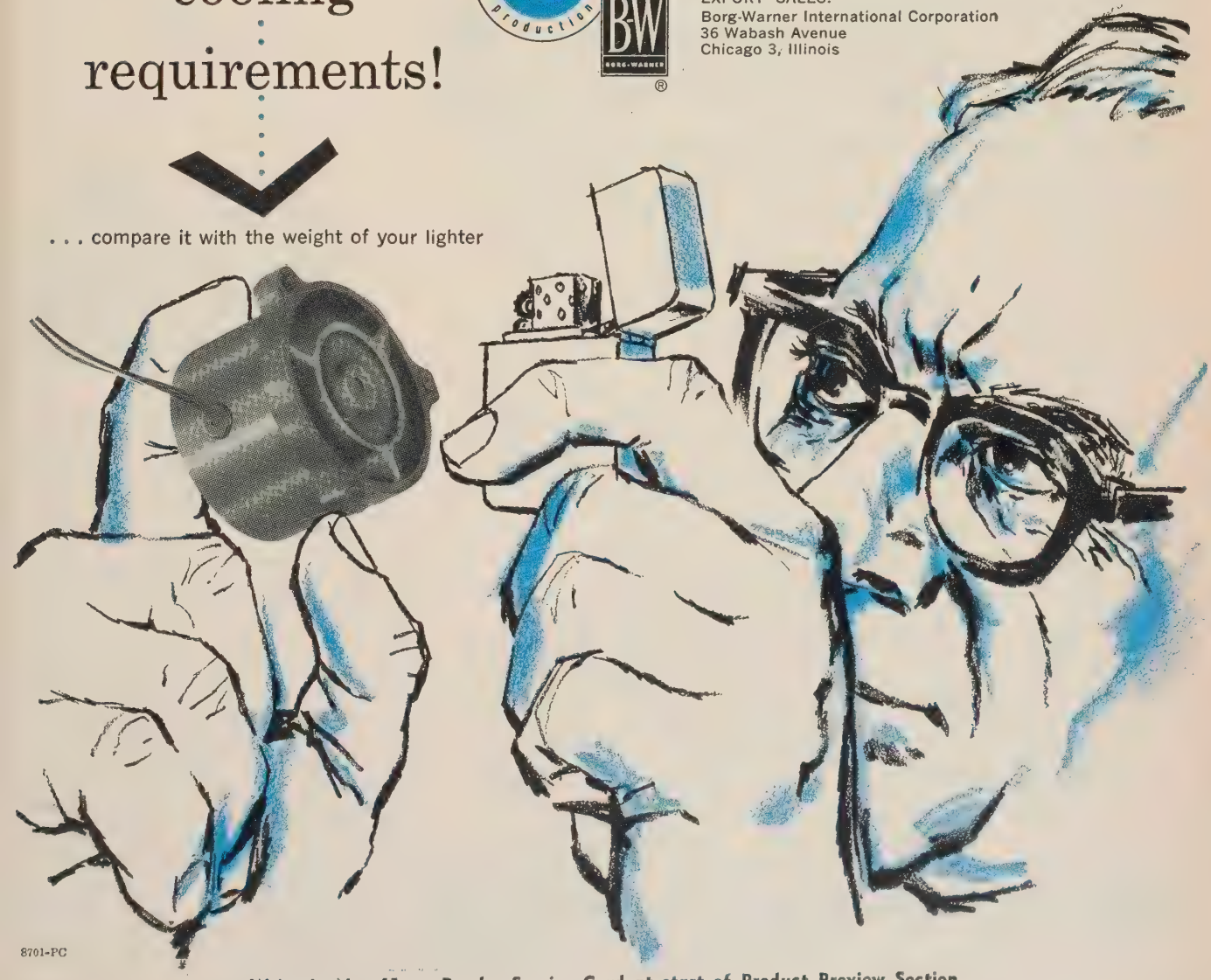

8701-PC

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**CHR Temp-R-Tapes are easy to apply ...economical...dependable in service**

Choose the right Temp-R-Tape for your job from a variety of types which combine some form of Teflon*, Fiberglas or Silicone Rubber backing with a silicone polymer adhesive. Temp-R-Tapes are all pressure-sensitive, even those which are thermal curing, and adhere securely to most materials, including Teflon, at extremely high temperatures. Each of these versatile tapes possess a superior combination of electrical, mechanical and physical properties suitable for a variety of applications where high dielectric strength, thermal stability, moisture resistance, durability, low coefficient of friction, non-stick properties, non-corrosiveness, non-aging characteristics or fuel resistance may be required.

**TYPICAL USES:**

Electrical — *slot lining; interlayer and interphase insulation; harness bundling; splicing; wrapping for microwave components, transformer coils, capacitors and high voltage cables.* Mechanical — *facings for film guides in electronic instruments, heat sealing bars, forming dies, chutes, guide rails, and for protection for metals and other materials being chemically cleaned or coated.*

**AVAILABLE FROM STOCK:**

¼" to 2" widths, 18 yd. and 36 yd. rolls and 12" width on liner by lineal yard. Special roll widths slit to order. Temp-R-Tape is sold nationally through distributors.

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*ELECTRICAL AND INDUSTRIAL SPECIALTY TAPES*

**CHR CONNECTICUT HARD RUBBER CO.**

*duPont TM

Main office: New Haven 9, Connecticut

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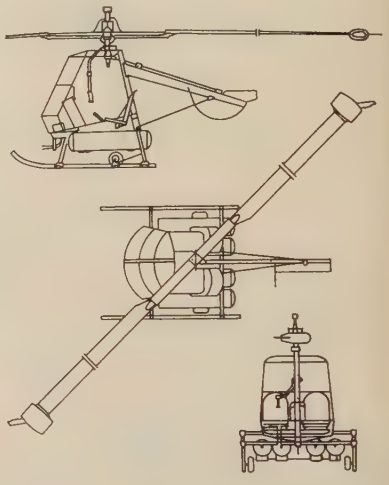
develops pitching characteristics (as a result of asymmetrical air flow over the ducts), Kellett is studying an ASP without ducts. Fixed guard rings around the rotor blades will protect personnel. The design will have a low silhouette and be narrow. Payload aim is 1000 lb.

**McDonnell XV-1**—A compound copter with a rotor and fixed wings and powered by a Continental R-975-19 engine. The rotor is unloaded 85 per cent. The aircraft has flown at 200 mph, showing no vibration. Its flying qualities are those of a conventional fixed wing aircraft, while its hover and low speed characteristics are typical of conventional copters, according to *McDonnell Aircraft Corp., St. Louis 3, Missouri.*



Length overall, 31 ft 10 in.; span, 26 ft; height, 10 ft 1 in.; main rotor diameter, 31 ft; tail rotors (two), 1 ft 3 in. (each); wing loading, 55 lb; gross weight, 5505 lb; useful load, 1228 lb; max cruise speed (SL), 170 mph; normal cruise speed (SL), 138 mph; SL rate of climb, 1300 fpm.

**Nederlandse NHI H-3 Kolibrie**—A two-seat, general-purpose copter designed and built by *Nederlandse Helicopter Industrie N.V., Papendrecht, Holland,* with a "self-adjusting" rotor. Tip drive, no-torque low disk loading, and high rotor inertia give double engine power in emergency. Two TJ-5A ramjet engines are installed in the blade tips. The tail rotor is powered through gear box and shaft from the main rotor. The engines have separate fuel feed. The Kolibrie has excellent maneuverability. No **113** on Card.

Length overall, 14.2 ft; height, 9.04 ft; main rotor diameter, 32.7 ft; disk loading, 2.18 psf; gross weight, 1540 lb; max useful load, 950 lb; fuel, 106 gal; max cruise speed, 56-62 mph; normal cruise speed, 32-35 mph; max range, 46 miles; fuel consumption: at cruise speed—105 gph, at max cruise speed—136 gph; service ceiling: 1540 lb—5250 ft, 1100 lb—9200 ft; hovering ceiling: in ground effect—2450 ft (1540 lb), 7900 ft (@ 1100 lb); SL rate of climb: 1540 lb—680 fpm, 1100 lb—2000 fpm.

**Omega BS-12D**—A copter for easy servicing in flying-crane and agricultural work. Two Lycoming 0-540-F1B5 engines mounted on outriggers to be completely accessible can be removed as units on their mountings. *Omega Aircraft Corp., New Bedford, Mass.*, is reportedly developing an Allison T63 shaft turbine version using three engines. No. **114** on Card.

Length overall, 34.5 ft; height, 13 ft; main rotor diameter, 39 ft; tail rotor diameter, 8 ft; gross weight, 4850 lb; useful load, 1450 lb; max cruise speed, 90 mph; normal cruise speed, 80 mph; hovering ceiling (in ground effect), 4000 ft.

**Piasecki PA-4A**—Claimed by *Piasecki Aircraft Corp., International Airport, Philadelphia 42, Pa.*, to be the first VTOL designed exclusively for radio control, this omni-directional quadrotor drone is said to maintain a perfectly level airframe and a constant heading under all flight conditions. Powerplant is a Lycoming VO-435-A1B of 260 hp. No. **114** on Card.

Length overall, 22 ft 3 in.; width, 22 ft 3 in.; height, 6 ft 7 in.; gross weight, 2500 lb. Fuel consumption, 18-20 gph.

**Piasecki PA-94**—Designed to carry 40-48 passengers or 15,000 lb cargo, this four-engine, high wing STOL transport uses the deflected-slipstream technique. Powered by four GE T58-8s of 1250 hp each. No. **115** on Card.

Length overall, 71 ft; span, 76 ft; height, 29 ft; wing loading, 49.5 psf; gross weight, 44,000 lb; useful load, 21,000 lb; normal cruise speed, 265 mph; takeoff distance over 50-ft obstacle, 1500 ft.

**Piasecki PA-101**—A single-rotor for military and commercial use. It will be powered by three GE T58-6 turbines of 1050 hp each. No. **116** on Card.

Length overall, 64 ft 6 in.; height, 16 ft 4 in.; main rotor diameter, 65 ft; tail rotor diameter, 10 ft 4 in.; gross weight, 25,000 lb; useful load, 12,000 lb; max cruise speed, 143 mph; normal cruise speed, 125 mph; range 280 miles (45-min reserve); hover ceiling, 20,600 ft (in ground effect); SL range of climb, 1280 fpm.

**Piasecki VZ-8P Airjeep**—Designed for VTOL Army battlefield operation "in the nap of the earth," the ducted-rotor VZ8P can fly between trees and other objects. An improved version, the PA-59H, has ground-

*more on next page*

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COHRlastic R-10470 silicone sponge rubber sheets have a dense, uniform, non-absorbing closed cell structure highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. COHRlastic R-10470 possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening.

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*** Missiles**
*** In-Flight Refueling**
*** Industrial Applications**

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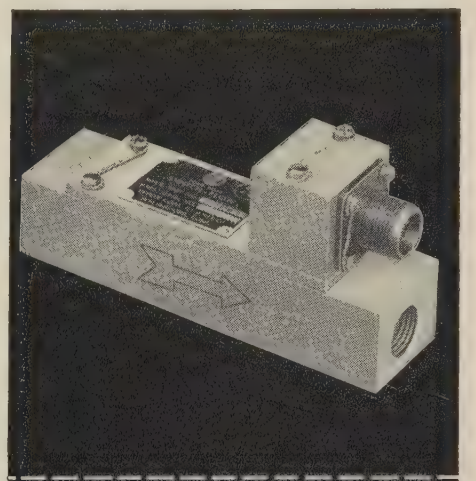
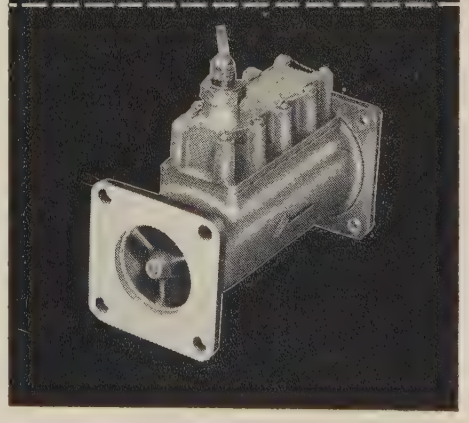
This Flow Switch (Revere part F-72530) has been used to determine proper coolant flow to Radar Klystron Tubes. Should coolant flow fall below safe levels, the Flow Switch, with built-in Glaswitch®, operates a warning light and simultaneously shuts down operating voltages to the tube, preventing costly tube failure. When proper coolant flow is restored, Flow Switch allows restoration of power. Settings available for various applications.



The Impeller Flowmeter (Revere part F-70705-2) finds application in industrial, missile and aviation flow measurement of a variety of liquids, without need of electronic amplifying equipment. Fuel flow totalizing information displayed on associated readout devices. Mates with AN standard parts. No internal pressure seals—excellent reliability.



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## V-STOL SPECS . . .

wheels for extended range and duration. Both versions are powered by Artouste IIs—the VZ-8P by the 425-hp —B, the PA-59H by the 400-hp —C.

VZ-8P: length overall, 26 ft 1 in.; width, 9 ft 5 in.; height, 6 ft 8 in.; gross weight, 2350 lb; fuel consumption, 52 gph.

PA-59H: length overall, 24 ft 5 in.; width, 9 ft 3 in.; height, 5 ft 10 in.; gross weight, 3670 lb; fuel consumption, 96 gph.

**Rotor-Craft RH-1 Pinwheel**—Designed to carry one fully armed soldier, this vehicle and its structure have been kept as simple as possible. The tip rockets on the rotor blades, weigh less than a pound each. The vehicle can fly with only one tip rocket firing. Liquid $H_2O_2$ monopropellant gives about 20 lb thrust from each rocket. The all-metal main rotor has folding blades carried on fully articulated hub. The single-blade tail rotor is belt-driven from the main rotor shaft. A small, fixed V-stabilizer is aft of the tail rotor. A privotal seat accommodates the pilot, who is secured by shoulder and waist straps. *Rotor-Craft Corp., 1850 Victoria Blvd., Glendale, Calif.*, designed and built the Pinwheel under Navy contract.

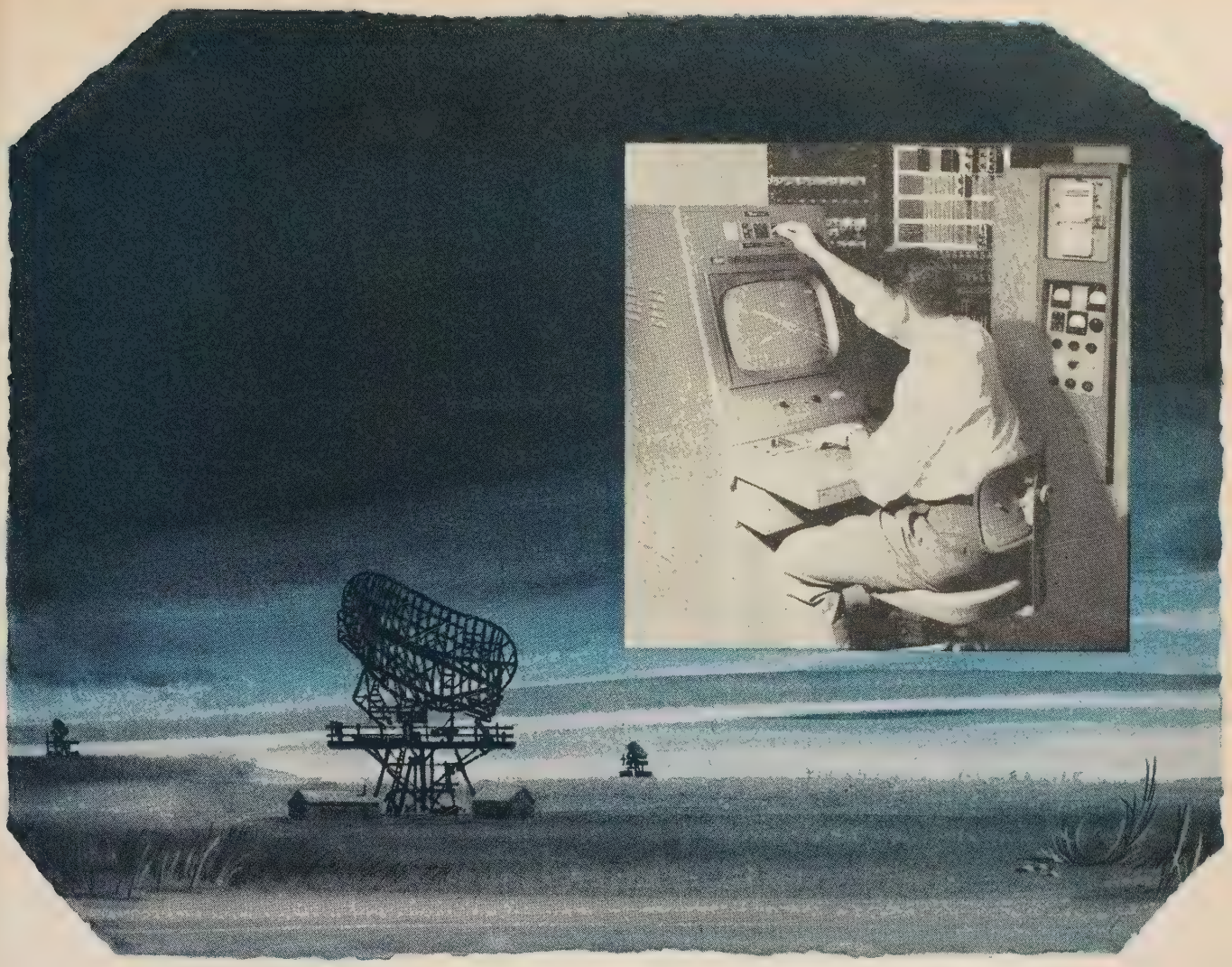
Overall length, 8 ft; height (pilot standing), 8 ft; overall width, 5 ft; main rotor diameter, about 16 ft; gross weight, 400 lb; weight empty, 165 lb; cruising speed, approx. 65 mph.

**Ryan Vertifan** — Combines VTOL with high speed forward flight. A fan or a set of fans is submerged horizontally in the wing. Possible powerplant is the GE X-353 lift fan engine, which has three components: a conventional jet engine, a diverter valve, and a lift fan. Fans can be adapted to the entire jet engine power range. Advantages cited by *Ryan Aeronautical Co., 2701 Harbor Drive, San Diego 12, Calif.*, for the Vertifan over other jet VTOLs: gross weight can greatly exceed the thrust, extended hovering periods call for relatively low fuel consumption; pure jet design gives a wider speed range.

**Ryan VZ-3RY Vertiplane**—Just after it had completed a very successful flight test program, after being turned

over to NASA, the Vertiplane crashed. Built for the Army, it is a two-seat VTOL research aircraft powered by one Lycoming T53-L-1 shaft turbine.

***more on page 88***



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Effective air defense requires high resolution for raid analysis and accurate tracking data for weapon control. Enemy jamming is intended to degrade resolution and accuracy, and saturate the data processing system.

Bendix, as a prime supplier of the "radar eyes" of air defense, is developing new radar and data processing techniques to permit weapon assignment and control in the face of such enemy jamming. A special simulation facility has been developed at the Bendix Systems Division to evaluate new techniques and concepts in real time. Both automatic and semi-automatic methods are being tested. The purpose of the facility is to establish the optimum balance of man and machine functions.

This Air Force program involves system analysis, equipment evaluation, computer design, human factors, and operations research. The results of the investigations are being used as a basis for planning future Air Force programs. It is typical of advanced systems programs being carried out by the Bendix Systems Division. Better engineers and scientists interested in pioneering systems of the future are invited to join this growing team.

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actual size

# BRISTOL chopper helps put Navy TARTAR on target

. . . Every component in the U.S. Navy's TARTAR, newest supersonic surface-to-air guided missile must meet the highest standards for statistical reliability.

No exception is the Bristol Syncroverter* chopper used in the TARTAR's guidance system. The TARTAR, produced for the Bureau of Naval Weapons by Convair (Pomona) Division of General Dynamics Corporation, is slated to form the primary antiaircraft weapon aboard destroyers and secondary antiaircraft batteries aboard cruisers.

The Bristol Syncroverter chopper has a long history as a component in U.S. guided missiles. It's the ideal miniature electromechanical chopper for use in d-c analog computers or wherever utmost reliability is required.

**BILLIONS OF OPERATIONS** have been completed without a failure on Bristol's continuing life tests—aimed at improving the Syncroverter's already superlative characteristics. Just one sample: A group of five choppers, with 400 cps drive and 12v, 1 ma resistive contact load have been going for more than 26,000 hours without failure. That's more than 2.96 years continuous operation or more than 37 billion complete cycles!

No matter what your chopper requirements, we're sure you can find the model you need among the wide selection of Syncroverter choppers and high-speed relays available . . . including low-noise, external coil types. For complete data, write: The Bristol Company, Aircraft Equipment Division, 150 Bristol Road, Waterbury 20, Conn. 0.15

*T.M. Reg. U.S. Pat. Off.

**BRISTOL** FINE PRECISION INSTRUMENTS FOR OVER SEVENTY YEARS

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## V-STOL SPECS . . .

The powerplant drives two three-bladed, wooden Hartzell props mounted on the wing. Large, underslung wing tip plates confine the slipstream within the flap span. The plane has flown for 17 minutes at less than 20 knots below 100 ft. For normal forward flight, the flaps are retracted. A jet deflection nozzle on the tailpipe provides adequate control during hovering flight. The tail assembly includes rudder, elevator, and variable incidence tailplane. Spoilers on the upper surface of each wing forward of the flaps take the place of ailerons.

Length overall, 27 ft 8 in.; span, 23 ft 5 in.; height, 10 ft 8 in. Gross weight, approx. 2600 lb.

**Scottish Aviation Twin Pioneer 3**—Prototype flew in late '58. Designed and built by *Scottish Aviation Ltd., Prestwick Airport, Scotland,* this 16-18-passenger high wing, fixed-gear STOL uses two Alvis Leonides 531/8B engines of 640 hp each. Props are three-bladed, metal, feathering, constant-speed, hydraulically-controlled de Havilland models. A general-purpose aircraft for military and civilian use, the Twin Pioneer has extendible leading edge and Fowler-type flaps on the wing. The fuselage is a light-alloy, stressed-skin semi-monocoque structure. The braced wing is a two-spar, light-alloy, stressed-skin structure; the tail a cantilever type with interchangeable elevators. No. **117** on Card.

Length overall, 45.25 ft; span, 76.5 ft; height, 12.25 ft; wing loading, 21.8 psf; gross weight, 14,600 lb; useful load, 4400 lb; normal fuel, 296 gal; long range fuel, 447 gal; max cruise speed, 138 mph; normal cruise speed, 134 mph; normal cruise range, 806 miles; max range, 1277 miles; fuel consumption, 42 gph (7000 ft, normal cruise speed); service ceiling, 20,300 ft; SL rate of climb, 1250 fpm; takeoff distance over 50-ft obstacle, 1150 ft; stall speed (power off, full flaps), 62 mph.

**Short SC-1**—An experimental delta wing VTOL research plane designed and built by *Short Bros. & Harland Ltd., Queen's Island, Belfast, Northern Ireland,* without a tailplane. Engines are five R-R RB-108s—four lift engines and a rear propulsion engine. The lift engines are in a central engine room in the fuselage. Each swings on an axis to that the thrust center can be directed fore or aft during transition from vertical to forward flight. A compressor bleed from all five engines supplies high pressure air to a common duct that feeds air nozzles for stability and control during hovering. Control nozzles are at the wing tips, tail, and nose; they are controlled by the electro-hydraulic autostabilizer.

Length overall, 23 ft 6 in.; span, 24 ft 5 in.; height, 10 ft 8 in. Takeoff distance, 0 ft.

**Sikorsky S-57 Convertiplane**—De-

*more on page 92*

# MISSILE STEEL PASSES ITS PHYSICAL AT Acme-Newport

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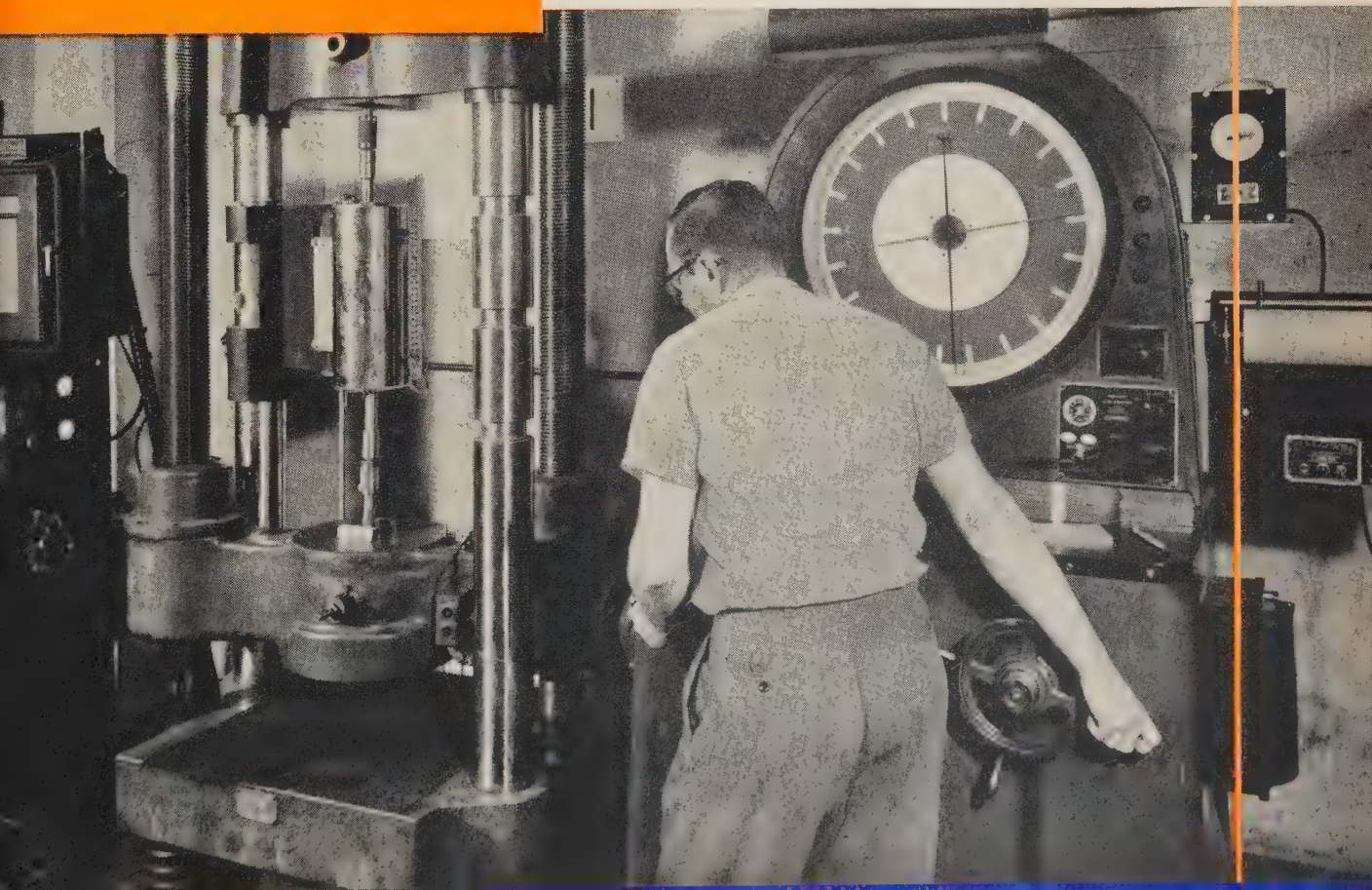

Effective deployment of tactical missiles and their supporting troops and equipment calls, today, for full *off-road mobility*. In this concept, FMC offers long and versatile experience, having since 1941 designed and built more types of military-standardized tracked vehicles than any other company in America.

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High Speed Tractor

**1959-T249**
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Armored Self-Propelled
Gun Chassis

**1960-M113**
Amphibious, Air-Droppable
Armored Personnel Carrier

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Propellant Metering
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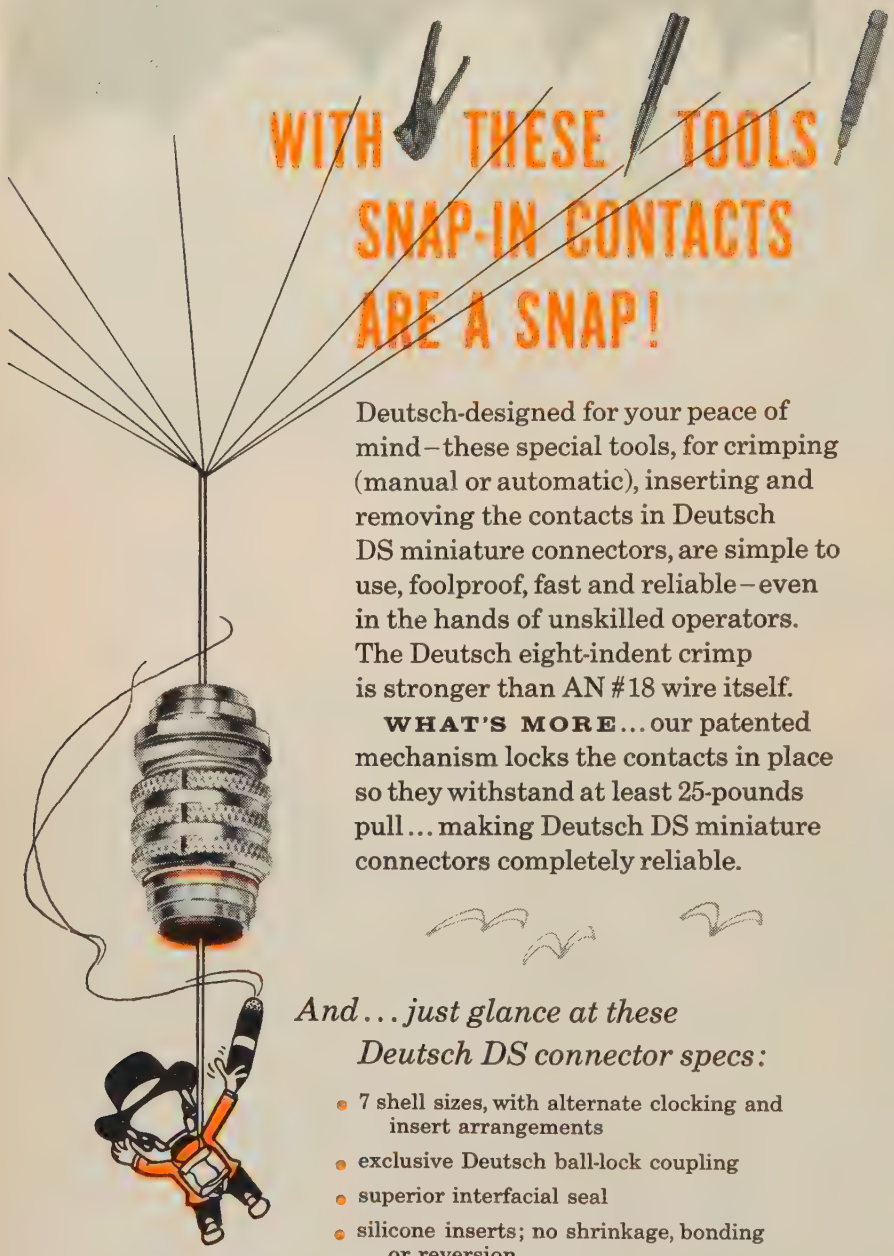

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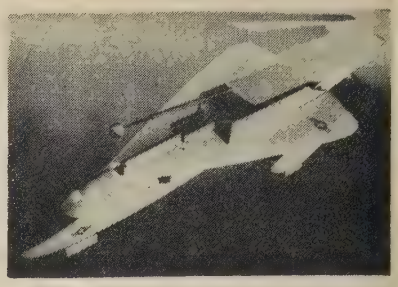
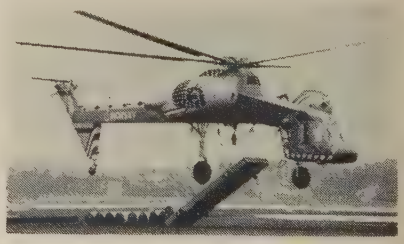


signed for true conversion from copter to fixed wing plane by completely stopping the rotor in forward flight. The entire rotor system can be retracted and stowed inside the airframe. The same power would be used for both vertical and high speed flight. Among the gains expected by *Sikorsky Aircraft Div., United Aircraft Corp., Stratford, Conn.,* from its concept are good control in vertical flight, transition, and high speed forward flight; about the same downblast during takeoff and hovering as with conventional copters; no extreme change in attitude between vertical and forward flight; less power than with most other VTOL designs; copter-type landing in case of complete power failure; lower noise levels than those of "brute force" VTOLs; clean, high speed shape with the rotor system stowed. The S-57 would be suited for rescue work, recon, interception, ground attack, anti-sub warfare, aerial ambulance missions, etc.

**Sikorsky S-60**—A large flying-crane copter using two P&WA R2800s. Main and tail rotor heads, transmission parts, blades, and drives shafts are the same as those on the S-56. No. **118** on Card.



Fuselage length, 65 ft; width, 27.3 ft; overall height, 17 ft; main rotor diameter, 15 ft; gross weight, 31,200 lb; useful load, 11,587 lb; normal fuel (usable), 666 gal; max cruise speed, 128 mph; range at normal cruise speed, 218 m; fuel consumption: normal cruise speed—187-250 gph, max cruise speed—287-383 gph; service ceiling, 10,800 ft; hover ceiling: in ground effect—3300 ft; out of ground effect—800 ft; SL rate of climb, 910 fpm.

**Sikorsky S-61L**—An amphibious copter powered by two GE CT-58-110 shaft turbines mounted over the cabin. Capacity is 25 passengers. Passenger door opens down into a stair that doesn't require a ramp. Main and tail rotors are five-bladed. No. **119** on Card.

*more on page 94*

**Out of Space Age achievements by Government and Industry will come better living for everyone**

Someday soon the art of weather forecasting will become more precise as the result of a network of meteorological satellites. Even weather *control* may become possible.

The first of these satellites, *Tiros I*, is already transmitting pictures of weather around the world. The booster that helped put it in orbit was a modified version of the reliable Douglas *Thor* IRBM. *Thor* is prime booster in the scientific "Discoverer" firings . . . has worked perfectly in over 85% of its space missions.

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*Thor* is one more proof that Douglas' extensive experience in missiles is a national asset, and that nothing can substitute for the imagination, experience and skills which Douglas has accumulated in nearly 20 years of missile development.

**TIROS** (Television Infrared Observation Satellites) would serve weather observers—relaying information on cloud cover, temperatures, solar radiation

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This big 18″ aluminum* impeller was originally *machined* from a rough forging...requiring many costly man-hours. Then Arcturus, utilizing techniques they have pioneered, developed a method for *forging* the vanes to the finished state shown above... saving considerably on material, eliminating all profile machining and reducing the cost of the finished part substantially. Grain flow follows the contour of the part, providing greatest possible strength.

This was no minor achievement as the impeller was an exceptionally difficult part to make by any known method. The vanes are approximately 3″ high and less than 1/16″ thick, yet extremely close tolerances were held.

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Fuselage length, 58.9 ft; width, 7.1 ft; overall height, 15.3 ft; main rotor diameter, 62 ft; tail rotor diameter, 10 ft; gross weight, 18,700 lb; useful load, 8441 lb; normal useable fuel, 390 gal; max cruise speed, 150 mph; normal cruise speed, 135 mph; range at max cruise (45-min reserve), 187 miles; range at normal cruise and reserve, 228 miles; fuel consumption: normal cruise speed—120-160 gph, max cruise speeds—146 gph; service ceiling, 9500 ft; hover ceiling: in ground effect—7500 ft, out of ground effect—5000 ft; SL rate of climb, 1640 fpm.

**Sikorsky S-62**—An amphibious utility copter powered by a GE CT-58-100 shaft turbine. Designed with a flying boat hull, it weighs much less than land types equipped with inflated pontoons for water landing. No. **120** on Card.

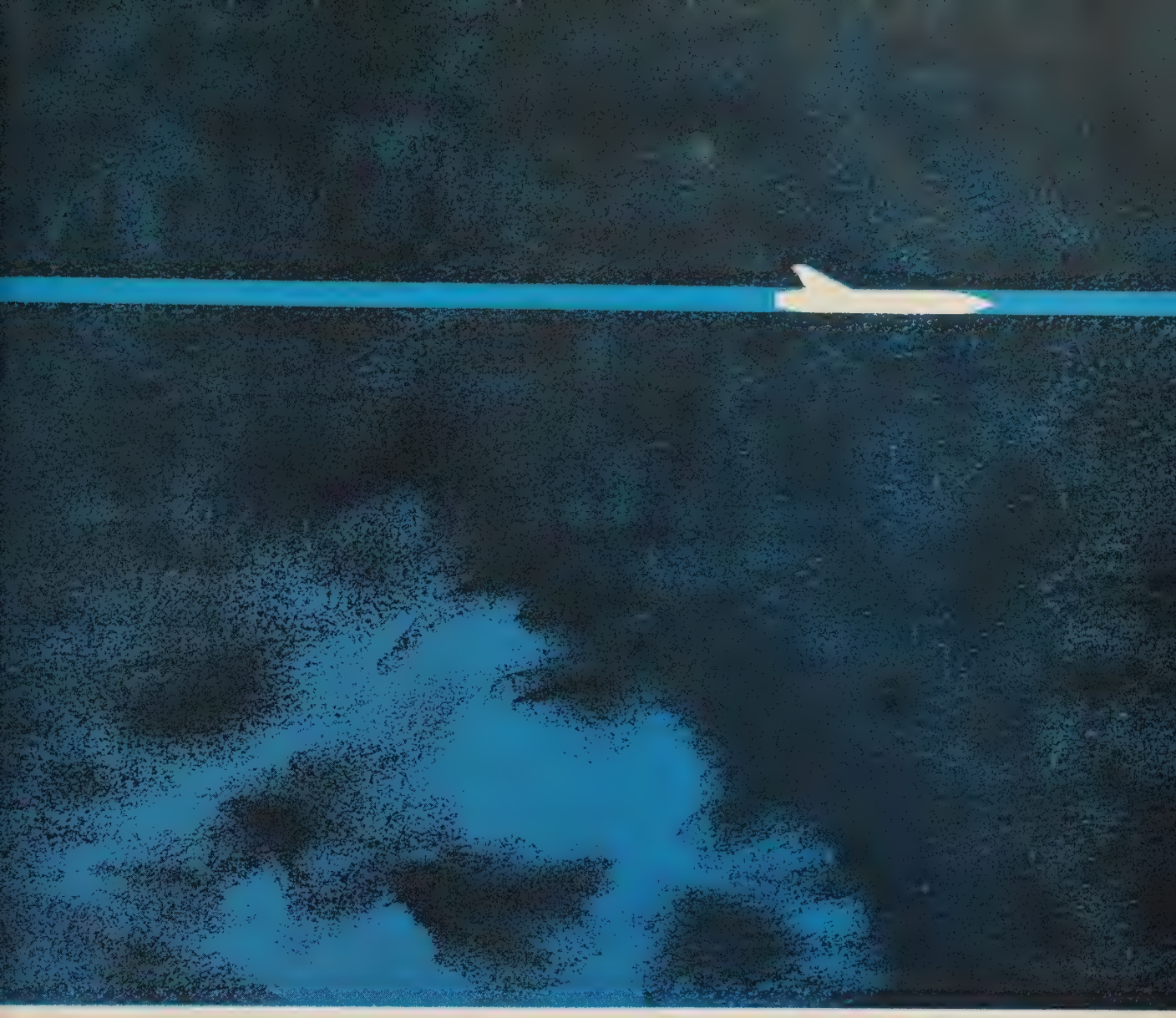
Fuselage length, 44.6 ft; width, 5.8 ft; height, 14.2 ft; main rotor diameter, 53 ft; tail rotor diameter, 8.8 ft; gross load, 7500 lb; useful load, 2818 lb; normal usable fuel, 182 gal; max cruise speed, 124 mph; normal cruise speed, 115 mph; range: max cruise speed—197 miles; normal cruise speed—212 miles; fuel consumption: normal cruise speed—52½-70 gph, max cruise speed—58½-70 gph; service ceiling, 15,700 ft; hover ceiling: in ground effect—15,800 ft, out of ground effect—12,000 ft; SL rate of climb, 1380 fpm.

**Sud-Aviation SA-3200**—A medium, three-turbine, single-rotor copter with a tail rotor designed to meet military and civil requirements. Powerplants are three Turmo III gas turbines. Twenty passengers or 24 troops can be carried. A swing tail is provided for

cargo loading. The main rotor has five blades. All fuel is carried externally in tanks on each side of the fuselage. *Sud-Aviation, 37 Bd. de Montmorency, Paris 16, France,* flew the prototype just a year ago. No. **122** on Card.

Length, 48 ft 10 in.; height, 15 ft 5

***more on page 98***



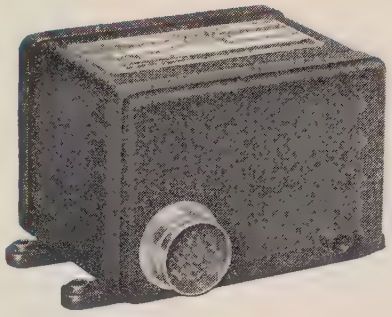
# PRECISE ALTITUDE CONTROL

## N A 4-INCH PACKAGE

he new Daystrom Barometric Altitude Controller has usually high frequency response to precisely position d maintain an aircraft or target drone at a constant rometric altitude—from below sea level to 125,000 feet. is 2¾ lb. unit is small enough to fit in the palm of your nd*...yet it has laboratory sensitivity that is better an 0.00036 psi! And simplified circuitry helps assure at st 1000 hours of reliable, maintenance-free operation.

the heart of this instrument is Daystrom's unique null-ance pressure transducer. It provides unusual accu-y, simplicity and economy for a variety of airborne plications... another example of Daystrom's ability to ate better instruments and systems in smaller, more nomical packages for military and commercial use.

r complete information, contact your Pacific Division resentative or write us for Data File SA-887-1



*Dimensions:
2.75" high
4.00" wide
3.50" deep

*Openings exist for qualified engineers*

**DAYSTROM, INCORPORATED**
**PACIFIC DIVISION**
9320 Lincoln Boulevard, Los Angeles 45, Calif.

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# TAPCO POW

MINIAPS is only slightly larger than a beer can. It is shown here actual size: 2¾" x 3¾" x 8¾6".

Advanced engineering projects offer a challenging career at TAPCO for qualified engineers and scientists. Write to Engineering Personnel Manager.

# ER SYSTEMS

# MINIAPS

## solid-fuel turbogenerator weighs only 4½ pounds

This miniature solid-fuel turbogenerator was developed within 4 months by TAPCO for such functions as fuzing, telemetering and guidance. It is a compact, lightweight, self-contained and self-regulated secondary power system. It operates reliably in temperature ambients from $-65°$ to $+160°$.

MINIAPS uses hot gas generated by solid fuel to power a turbine that drives an electric generator at 60,000 rpm. Turbine and generator are on a single shaft. Five outputs of AC and DC are produced, with AC frequencies strictly governed by transistorized speed controls.

The version pictured weighs only 4½ pounds, yet produces 60 watts of power for 90 seconds duration. Other versions produce up to 200 watts. Duration of outputs can be varied by increasing or decreasing size of propellant grain.

TAPCO's many years of experience in the design and manufacture of turbo-machinery was an important factor in the development of MINIAPS. Other TAPCO power systems, now operational or under test, include classical missile APU's, hydraulic actuators, hot-gas actuation systems, solar and nuclear systems, solid-fuel and hydrazine gas generators, and re-entry turbines.

**TAPCO GROUP**

***Thompson Ramo Wooldridge Inc.***

Dept. SA-660 • Cleveland 17, Ohio

DESIGNERS AND MANUFACTURERS FOR THE AIRCRAFT, MISSILE AND SPACE, ORDNANCE, ELECTRONIC AND NUCLEAR INDUSTRIES.

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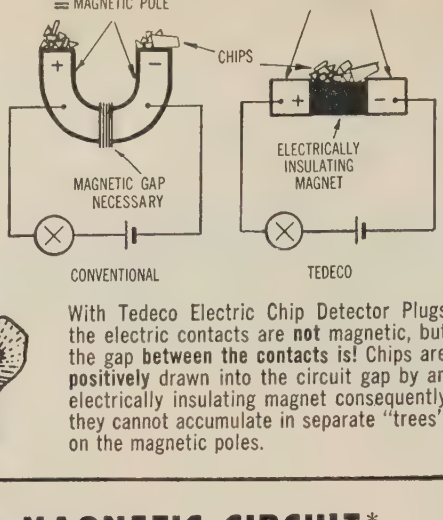
# WANT TO BE POSITIVE ABOUT CHIPS?




With Tedeco Electric Chip Detector Plugs the electric contacts are **not** magnetic, but the gap **between the contacts is!** Chips are **positively** drawn into the circuit gap by an electrically insulating magnet consequently they cannot accumulate in separate "trees" on the magnetic poles.

## TEDECO'S NEW MAGNETIC CIRCUIT* IMPROVES CHIP PLUG RELIABILITY

TEDECO ELECTRIC CHIP DETECTORS employ an advanced, patented magnetic-electric circuit which assures positive accumulation of chips in the gap between—not on—the electric contacts. This design provides for vastly increased chip retaining capacity and for positive action toward activating the signal. Tedeco Electric Chip Detectors are designed for use under the pressures, temperatures and chemical conditions in MIL-L-7808 oils or hydraulic fluids in engines, auxiliary drives, superchargers, constant speed drives and hydraulic systems.

Tedeco Catalog No. 3-60 presents the full line of Tedeco Electric Chip Detectors from the smallest sizes for the most compact hydraulic drives up to the large models for big oil sumps. There are standard, and self closing types (for quick, visual inspection without oil drain), for temporary "probe" testing or for permanent panel signal wiring, with MS connectors. For use with O-rings in AND 10050 ports or for AN 900 gaskets. Write for your copy of Catalog No. 3-60—or let us submit a special proposal.

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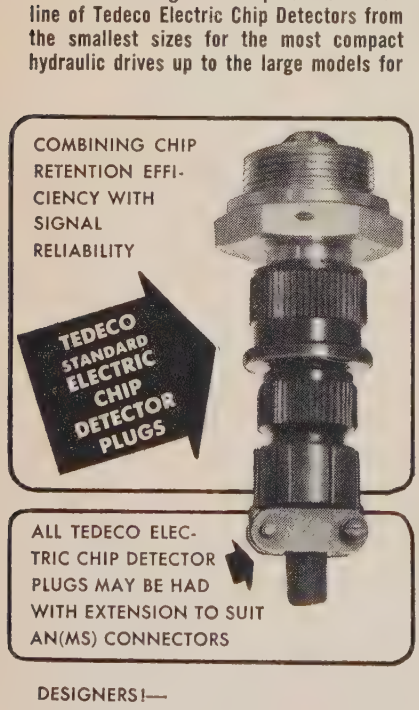
COMBINING CHIP RETENTION EFFICIENCY WITH SIGNAL RELIABILITY
TEDECO STANDARD ELECTRIC CHIP DETECTOR PLUGS
ALL TEDECO ELECTRIC CHIP DETECTOR PLUGS MAY BE HAD WITH EXTENSION TO SUIT AN(MS) CONNECTORS

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**TECHNICAL DEVELOPMENT COMPANY**
**305 SOUTH CHESTER PIKE, GLENOLDEN, PA.**

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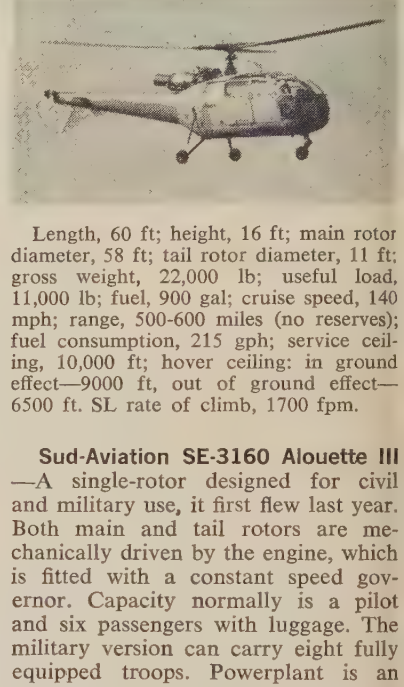
in.; main rotor diameter, 49 ft 2 in.; tail rotor diameter, 8 ft; gross load, 17,600 lb; useful load, 7720 lb; fuel, 800 gal; cruise speed, 125 mph; range (no reserve), 500 nm; fuel consumption, 165 gph; service ceiling, 9800 ft; hover ceiling (in ground effect), 6700 ft.

**Sud-Aviation SA-3210**—This somewhat larger and heavier version of the SA-3200 is powered by three Turmo IIICs of 1250 hp each. The rotors are the same as on the 3200, but the hull has been designed for amphibious operations. Tricycle landing gear is provided, as a cargo loading door. No. **123** on Card.



Length, 60 ft; height, 16 ft; main rotor diameter, 58 ft; tail rotor diameter, 11 ft; gross weight, 22,000 lb; useful load, 11,000 lb; fuel, 900 gal; cruise speed, 140 mph; range, 500-600 miles (no reserves); fuel consumption, 215 gph; service ceiling, 10,000 ft; hover ceiling: in ground effect—9000 ft, out of ground effect—6500 ft. SL rate of climb, 1700 fpm.

**Sud-Aviation SE-3160 Alouette III**—A single-rotor designed for civil and military use, it first flew last year. Both main and tail rotors are mechanically driven by the engine, which is fitted with a constant speed governor. Capacity normally is a pilot and six passengers with luggage. The military version can carry eight fully equipped troops. Powerplant is an Artouste IIIB shaft turbine of 870 hp, derated to 550 hp. Tricyle landing gear. Readily installed equipment includes cargo sling, rescue hoist, floats, litter carriers, etc. No. **124** on Card.

Length, 33 ft; height, 9 ft 8 in.; main rotor diameter, 36 ft 1 in.; tail rotor, 6 ft ½ in.; gross weight, 4630 lb; useful load, 2300 lb; fuel, 153 gal; cruise speed, 115 mph, range (no reserves), 300 nm; fuel consumption, 48 gph; service ceiling, 13,000 ft; hover ceiling: in ground effect—13,000 ft; out of ground effect—7300 ft.

**Umbaugh 18**—An autogiro tricycle-gear type built by *Umbaugh Aircraft Corp., Hagerstown, Md.* Powerplant is one Lycoming 0-360-A1A, driving two-position props. No. **125** on Card.

Length, 21.6 ft; height, 9.4 ft; gross weight 1800 lb; useful load, 585 lb; max cruise speed, 100 mph; normal cruise, 95 mph; range, 307-335 miles; hovering ceiling (out of ground effect), 16,000 ft; SL rate of climb, 1000 fpm.

**Vertol YHC-1B Chinook**—An advanced tactical copter that can carry

*more on page 100*

FOR THE AIR FORCE, MSVD developed experimental 12-foot ablating ICBM re-entry vehicle, the RVX-2, largest ever to be recovered. Vehicle, with its recovery package (upper left) developed for General Electric by Cook Research Laboratories, is shown here being hauled on board ship.

MISSILE AND SPACE VEHICLE DEPARTMENT

*...center for missile and space technology research and development at General Electric*

# Progress in search and recovery

With each recovery of a space vehicle, scientists gain important new knowledge about the environment of space and its potential effect on man and the operation of vehicles and equipment. As more advanced vehicles are developed for space flight—some with life aboard—successful location and recovery become increasingly vital.

General Electric's Missile and Space Vehicle Department pioneered in the development of space vehicle search and recovery techniques as part of its re-entry and recovery vehicle program for the U.S. Air Force. MSVD developed and built the first payload to be recovered from space—an 18-inch data capsule ejected from an Air Force Thor re-entry vehicle on June 13, 1958. Many such data capsules have since been recovered from both Thor and Atlas flights—some carried cameras providing films from space. MSVD also developed and built the 12-foot long, one-ton re-entry vehicle shown above which the Air Force recovered on July 21, 1959—the largest to be returned to date. Today, as MSVD builds and flight tests more complex vehicles, it is continually expanding and improving its already successful search and recovery program.

Currently, this search and recovery experience is being applied to the development of such important space programs as the Air Force "Discoverer" recovery satellites and NASA's radiation research recovery vehicles (NERV).

For more information about MSVD's work in search and recovery, write to Section 160–79, General Electric Co., Missile and Space Vehicle Department, Philadelphia 4, Penna.

GENERAL ELECTRIC

MISSILE AND SPACE VEHICLE DEPARTMENT

*A Department of the Defense Electronics Division*

*Scientists and Engineers interested in career opportunities in Space Technology, contact Mr. T. H. Sebring, Dept. 160, MSVD*

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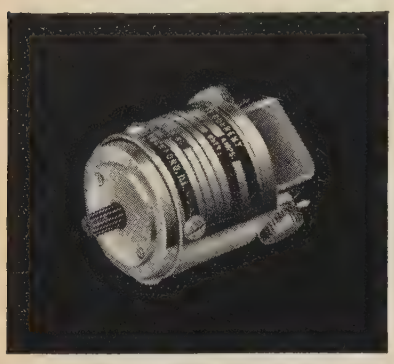
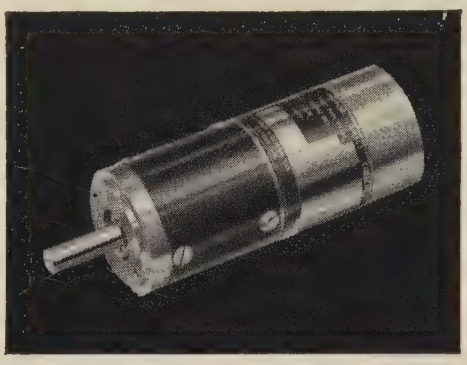
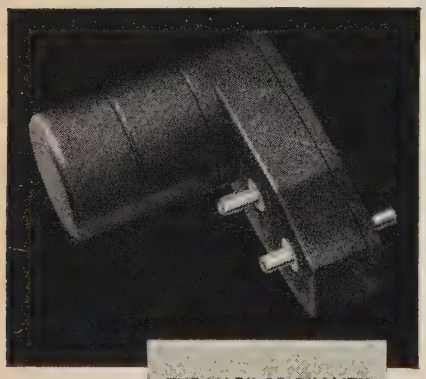
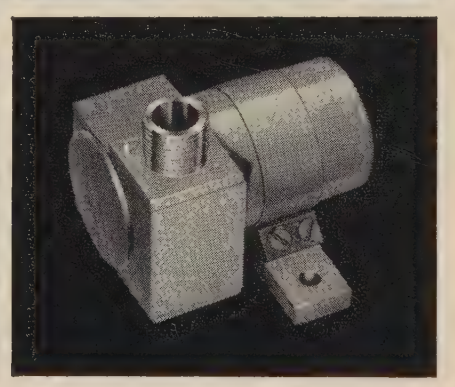
*Precision permanent magnet reversible motors...gearheads, blowers, and right-angle drives...for airborne and industrial applications*

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Barber-Colman offers a large selection of compact, high-quality d-c motors with outputs up to 1/10 hp. Compact design . . . 1¼" to 1½" diameters. Various mountings and speeds . . . several sizes and styles of gearheads and blowers. Integral radio noise filters, magnetic brakes, and governors available for most basic designs. Right-angle drives and multiple-shaft outputs also available for special applications.

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WITHSTAND AIRCRAFT AND MISSILE AMBIENTS

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SMOOTH RUNNING...LOW COGGING AND RIPPLE

WRITE FOR NEW QUICK REFERENCE FILE on the complete line of Barber-Colman electrical components. Includes detailed specifications on a-c and d-c motors, tach generators, blowers, gearheads, relays.

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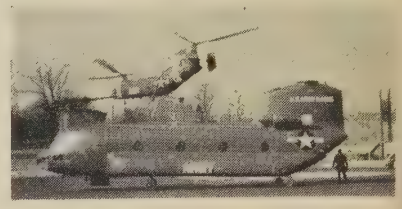
ballistic missiles. A tandem rotor design, it is powered by two Lycoming T55-L-5s. Five Chinooks have been ordered by the Army from *Vertol Div., Boeing Airplane Co., Morton, Pa.*



Length, 51 ft; width, 90 in.; height, 18 ft 6 in.; rotor diameter, 59 ft; gross weight, 28,000 lb; useful load, 11,892 lb; fuel, 630 gal; cruise speed, 150 mph; range (cruise speed, 5000 ft, standard day), 228 miles; service ceiling, 13,500 ft; hover ceiling: in ground effect—8500 ft; out of ground effect—7200 ft; SL rate of climb (vertical), 2150 fpm.

**Vertol 107-II**—A 25-passenger, two-crew copter powered by two GE T58 shaft turbines and using the standard Vertol tandem rotor configuration. No. **126** on Card.

Length, 44 ft 7 in.; cabin width, 72 in.; height, 16 ft 10 in.; rotor diameter, 50 ft; gross weight, 18,400 lb; useful load, 9167 lb; fuel, 360 gal; normal cruise speed, 150 mph; range (cruise speed, 5000 ft, standard day), 272 miles; service ceiling, 13,700 ft; hover ceiling: in ground effect—7800 ft; out of ground effect—6500 ft; SL rate of climb, 1240 ft (vertical).

**Westland Belvedere** — Formerly made by Bristol, this tandem rotor copter built by *Westland Aircraft, Ltd., Westland Aircraft Works, Yeovil, Somerset, England,* is the 192-2, powered by two Napier Gazelles of 920-shp each. It was designed for troop transport, ambulance, supply dropping, air-sea rescue, and is equipped for day and night operations. Additional fuel tanks, providing a total fuel capacity of 1080 Imp gal, can be installed in the fuselage for ferrying missions. The cabin is 24 ft 1 in. long and can carry 18-25 armed troops. No. **127** on Card.

Length overall, 89 ft 9 in.; height to rotor, 17 ft; rotor diameter, 48 ft 8 in.; gross weight, 18,000 lb; useful load, 6000 lb; max cruise speed, 138 mph; normal cruise speed, 115 mph; normal range (45-min reserve), 400 miles; hover ceiling (free air), 5000 ft. SL rate of climb, 1400 fpm.

**Westland P-531 Wasp**—Designed by Saunders-Roe, this five-seat, Turbo-powered copter first flew in July '58. Missions include liaison, light cargo, casualty evacuation, recon, training, etc. The Blackburn-Turboméca engine has been greatly derated to provide a supercharged gas turbine effect. Performance thus is largely independent of most climatic and altitude conditions. The four-bladed main

*more on page 104*

***AC Seeks and Solves the Significant***—AC has earned an enviable reputation for scientific accomplishment with national defense projects such as AChiever inertial guidance systems. But AC is not limiting its goal to leadership in the international technological race. Utilizing scientific "fallout," AC is also increasing its development of significant new commercial products. / This, too, is AC QUESTMANSHIP: the scientific quest for new ideas, methods, components and systems . . . to promote AC's many projects in guidance, navigation, control, detection and communication. / In the commercial field, AC is already producing communications systems, automotive controls and fuel controls for gas turbine engines. Some day they may even add such advanced projects as systems controls for "ground effect vehicles." According to Mr. B. H. Schwarze, AC Director of Commercial Engineering, "the proper application of scientific 'fallout' to commercial products leads to diversified career opportunities." / You may qualify for our specially selected staff . . . if you have a B.S., M.S. or Ph.D. in the electronics, scientific, electrical or mechanical fields, plus related experience. If you are a "seeker and solver," write the Director of Scientific and Professional Employment, Mr. Robert Allen, Oak Creek Plant, 7929 So. Howell Ave., Milwaukee, Wisc.

GUIDANCE / NAVIGATION / CONTROL / DETECTION / COMMUNICATIONS / AC SPARK PLUG The Electronics Division of General Motors

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# MARQUARDT PAT-C* SYSTEM MAKES POSSIBLE PRECISION SPACE CONTROL

## New control gives 3500 to 1 modulation and .001 pound-seconds impulse

Orbit correction, station keeping and attitude control of a 24-hour surveillance satellite which must orbit in a fixed position 24,000 miles above a predetermined point on earth, is but one unique application of PAT-C—position, attitude, trajectory control system—a development of The Marquardt Corporation's Controls and Accessories Division.

The PAT System is a highly responsive jet reaction control which controls the flight path, the position and attitude of a space vehicle as a result of intelligence inputs from the vehicle guidance system or ground control. The system is capable of providing the necessary corrective action based on simple positions and velocity air signals or will respond to the demand of complex guidance computers in the system. The thrust level can be adjusted over a range of 3500 to one (or more in some cases) with the same set of rocket nozzles; proportional control of thrust from 0 to full thrust is possible. Impulse imparted to the vehicle can be controlled accurately over a wide range down to a few milliseconds in duration—with a one lb. thrust nozzle as low as 0.001 pound-seconds. In the attitude control mode, the PAT system can maintain pointing accuracies not possible with other systems due to its low propellant consumption in limit cycle operation.

In a typical case, an accuracy of 0.1 seconds of arc can be held for 1000 hours with 40 lbs. of propellant.

Marquardt's fifteen years of research, development and production has resulted in state-of-art advancements in a wide range of electronic, electro-mechanical, pneumatic and hydraulic controls and accessories. For example, a pneumatic servo actuator is now available for 1600°F service—and severe nuclear radiation environments.

**For additional information concerning the PAT-C System or other C & A capabilities, contact Dick Oblinger, Chief Applications Engineer-Controls and Accessories, The Marquardt Corporation.**

*Engineers and Scientists experienced in these or related fields will find it rewarding to discuss their career futures with Marquardt. Founded in 1944, Marquardt now has a staff of 5,000—two out of three are professional people. The company's growth is a parallel to the atmosphere of challenge and rewarding accomplishment that has existed since the firm's beginning.*

Shown in photograph below—Marquardt engineers discuss a full scale mock-up of a complete self-contained PAT-C unit designed for application to space vehicles.

CONTROLS & ACCESSORIES DIVISION

THE Marquardt CORPORATION

16555 SATICOY STREET, VAN NUYS, CALIFORNIA

ASTRO ◆ COOPER DEVELOPMENT DIVISION
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CORPORATE OFFICES: VAN NUYS, CALIFORNIA

*POSITION—ATTITUDE—TRAJECTORY CONTROL SYSTEM

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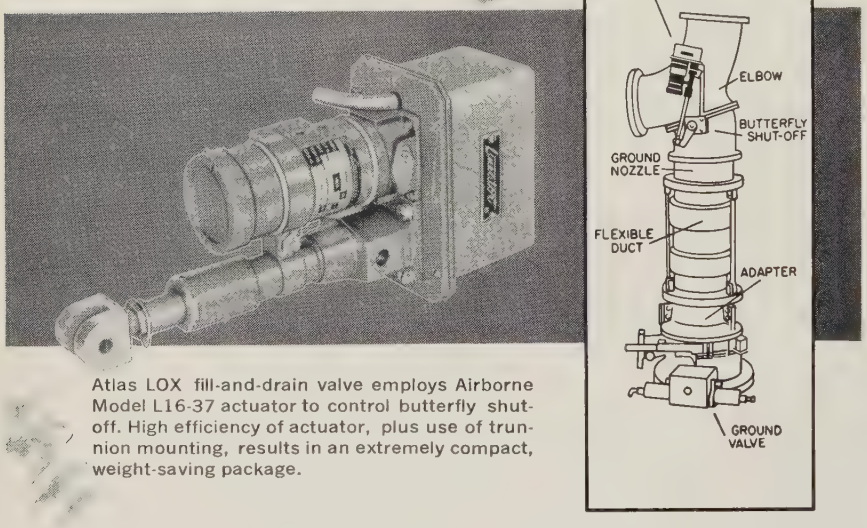
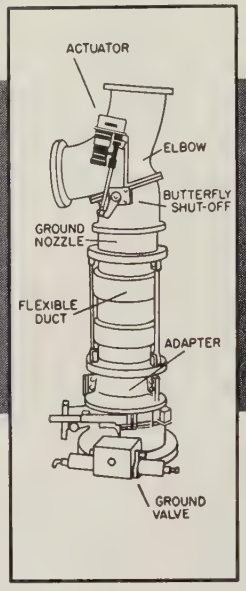
# AIRBORNE ACTUATOR SPECIFIED FOR RELIABLE CONTROL OF LOX VALVE






Atlas LOX fill-and-drain valve employs Airborne Model L16-37 actuator to control butterfly shut-off. High efficiency of actuator, plus use of trunnion mounting, results in an extremely compact, weight-saving package.

You will find Airborne electromechanical actuators in the componentry of a number of operational missiles and space vehicles. And for good reason. Their reputation for quality and their record of reliability — not only on missiles but also on many famous aircraft — are outstanding.

In the application shown it is the actuator's function to rotate an off-center butterfly shutoff in a liquid oxygen valve designed for the Atlas ICBM by Fairchild's Stratos Division. Reliability requirements are high, particularly in view of the temperature extremes and heavy "g" forces imposed by the operating environment. And the function of holding the shutoff closed is critical, because the liquid oxygen tanks require pressurization at all times to structurally support them.

Also vitally important in designing the missile-borne portion of the valve was weight. In the case of the actuator, Airborne held weight to 3.6 lb., while providing for an operating load of 600 lb. and a maximum static load of 2000 lb.

If you have requirements in electromechanical actuation — linear or rotary — for missiles or aircraft, contact any of our offices for further information or proposals. Or write for new Catalog GC-60.

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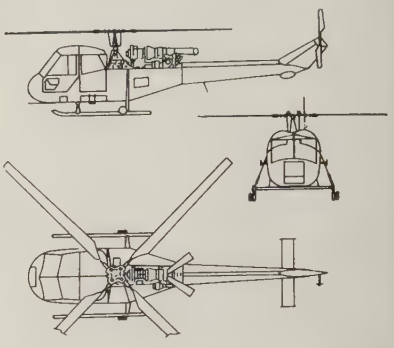
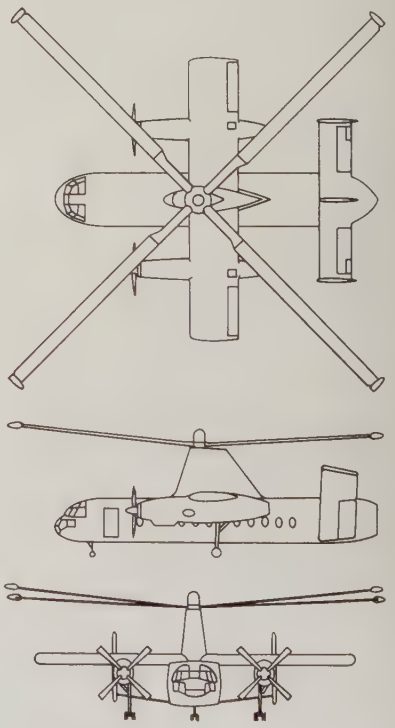
rotor gives low vibration levels and control forces throughout the speed-altitude range. The tail rotor is two-bladed. The Wasp is designed for easy maintenance under field conditions. No. **128** on Card.



Length overall, 39 ft 8 in.; height to main rotor, 8 ft 10 in.; main rotor diameter, 32 ft 2 in.; tail rotor diameter, 6 ft 2 in.; gross weight, 5000 lb; useful load, 1844 lb; fuel, 160 Imp. gal; normal cruise speed, 115 mph; normal range (45-min reserve), 250 miles; hover ceiling (free air), 9000 ft; SL rate of climb, 1490 fpm.

**Westland Rotodyne**—Formerly the Fairly Rotodyne, this twin-Tyne-powered fixed wing VTOL is provided with a four-blade main rotor for vertical flight. The rotor is driven by pressure-fed tip jets. The two 5250-shp Tynes also drive props for forward flight, in which 60 per cent of the lift is provided by the fixed wing. The cabin holds 57-65 passengers in addition to pilot and copilot. Inside it is 50 ft long, with 3270 cu ft capacity. The landing gear is retractable. Fuel is stored in the wings. Kaman holds the U.S. license on the Rotor-



**more on page 108**

The Lunar Space Station project at Martin is one of astonishing magnitude, for it coordinates practically all areas of scientific thought into one common objective: *sustaining life in outer space.* If you have the scientific or engineering talent required to aid in the fulfillment of this objective, we urge you to write immediately to N. M. Pagan, Dir. of Tech. & Scientific Staffing, The Martin Company, (Dept. AA-12), P. O. Box 179, Denver 1, Colo.

**MARTIN**
DENVER

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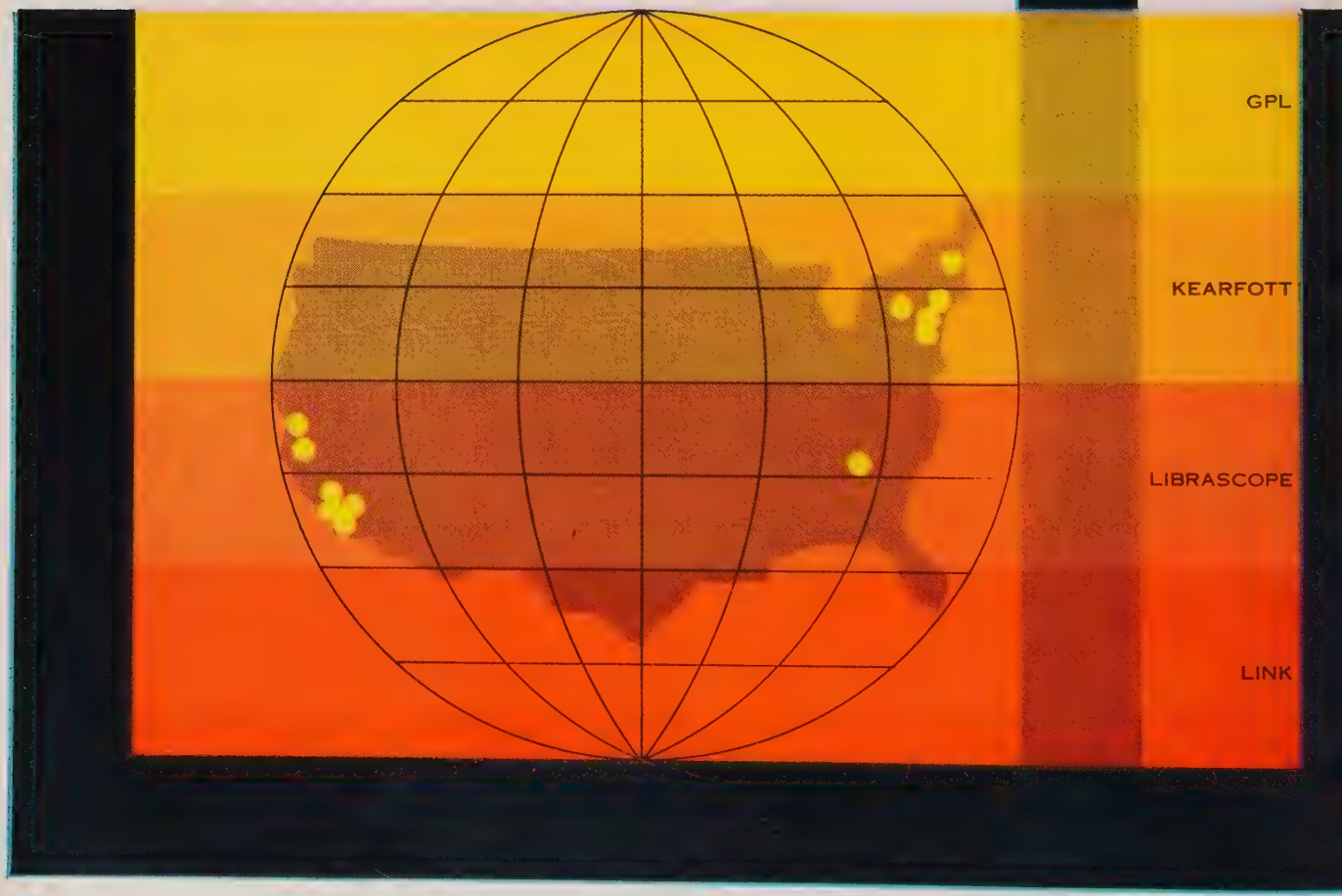
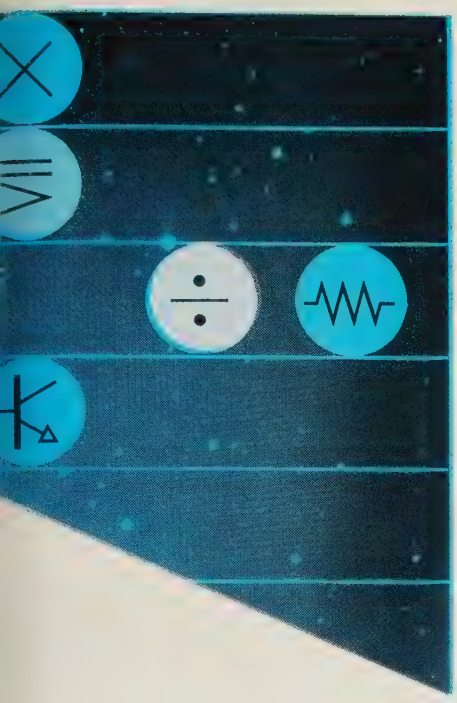
GENERAL PRECISION...ELECTRONICS TO THE FOURTH POWER





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# STALWART PRODUCES PRECISION CUSTOM RUBBER PARTS TO YOUR EXACT SPECIFICATIONS

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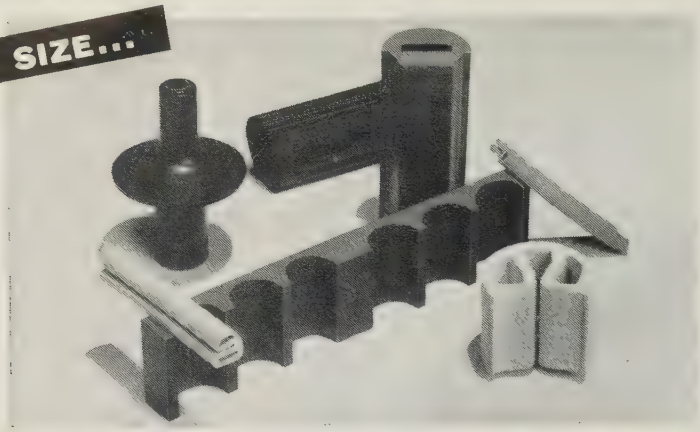
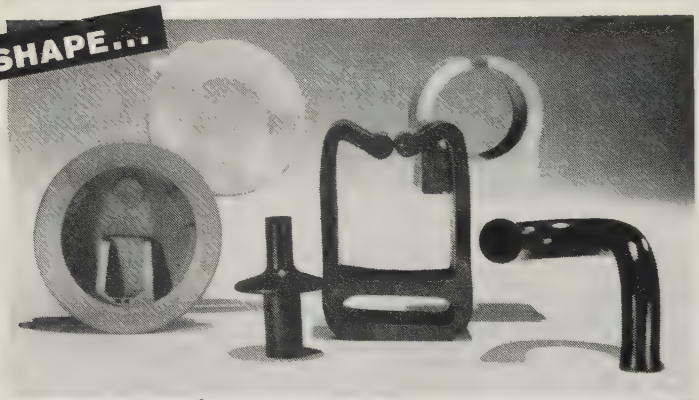


**ANY SHAPE...**



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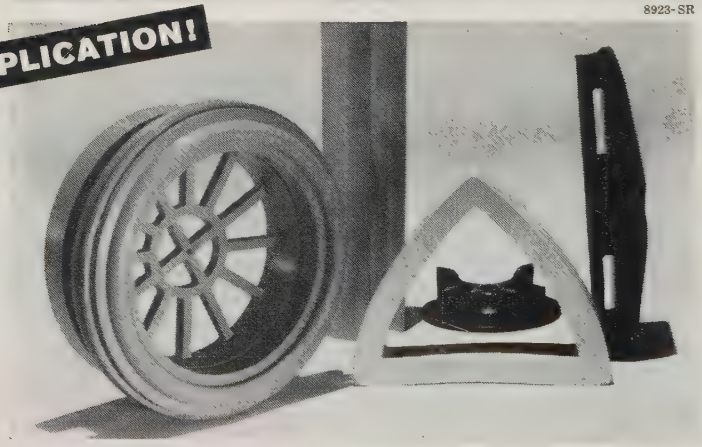

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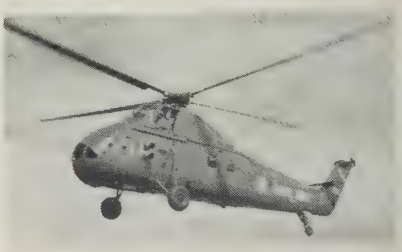
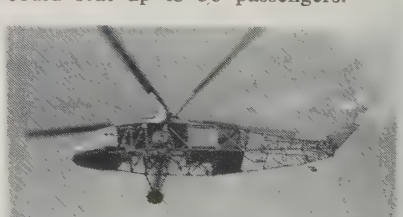
Length overall, 104 ft; height to rotor, 23 ft 2 in.; rotor diameter, 104 ft; gross weight, 53,000 lb; useful load, 18,500 lb; normal cruise speed, 201 mph; normal range (45-min reserve), 656 miles.

**Westland Wessex**—Powered by a Napier Gazelle shaft turbine mounted in the nose and driving both main and tail rotors (of four blades each), the Wessex looks like a Sikorsky S-58 (from which it originated). Designed for ASW work, it carries a crew of two with dual servo controls. Twelve passengers and luggage or eight stretchers can be carried. No. **130** on Card.



Length overall, 65 ft 10½ in.; height to main rotor, 14 ft 3 in.; main rotor diameter, 56 ft; tail rotor diameter, 9 ft 4 in.; gross weight, 12,600 lb; useful load, 4000 lb; fuel, 300 Imp. gal; max cruise speed, 145 mph; normal cruise speed, 126 mph; hover ceiling: in ground effect—7000 ft. free air—5000 ft. SL rate of climb, 1750 fpm.

**Westland Westminster**—The largest twin-turbine, mechanically driven copter of single-rotor design in the free world. A crane-transporter type, it is powered by two Napier Elands of 3650 shp each. The cockpit of the prototype seats a pilot, a co-pilot and two observers. A transport version could seat up to 50 passengers.



Length overall, 87 ft 11 in.; height to main rotor, 18 ft 3 in.; main rotor diameter, 72 ft; tail rotor diameter, 15 ft; gross weight, 33,000 lb; useful load, 11,335 lb; fuel, 800 Imp. gal; max cruise speed, 150 mph; normal cruise speed, 115 mph; normal range (45-min reserve), 400 miles; hover ceiling (in ground effect), 14,000 ft; SL rate of climb, 2350 fpm.



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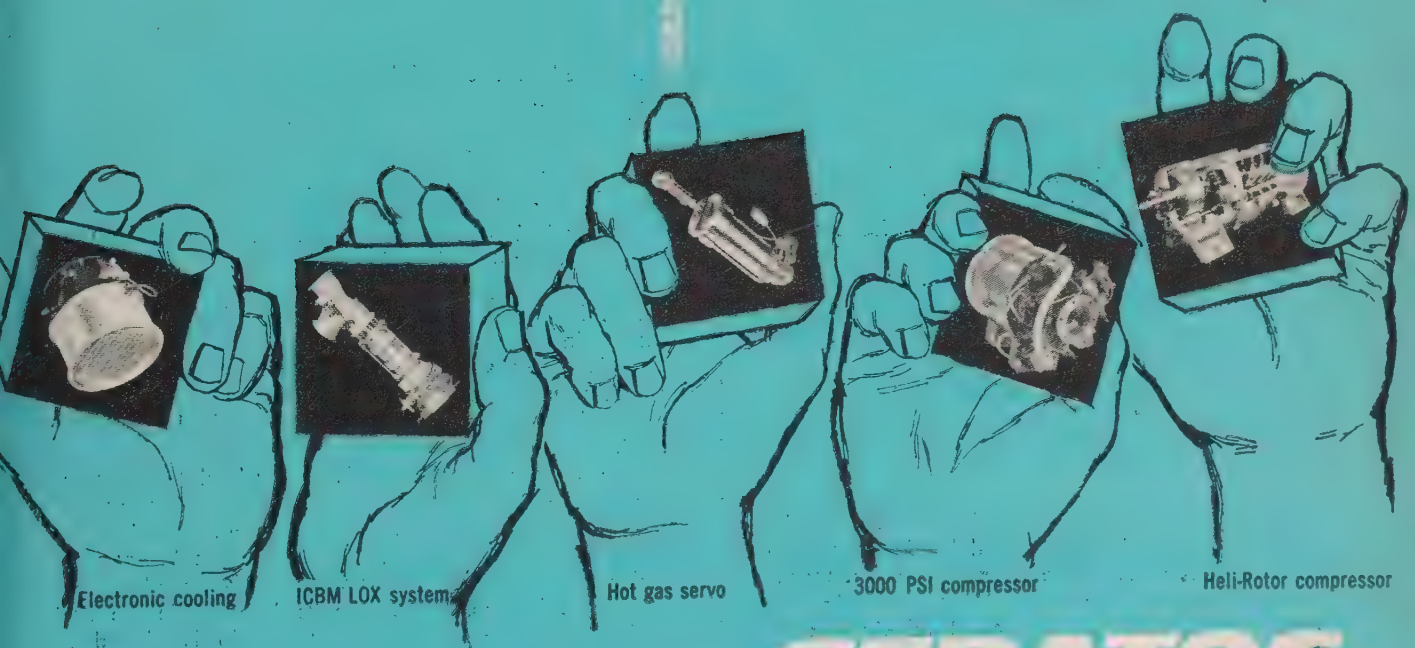


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# Honeycomb construction

## predominates in B-70 structure

**The structural design of the B-70 points the way towards the radically new approaches that will be needed in the next generation of supersonic transports. This exclusive S/A article is the first to show how honeycomb is actually used on the B-70.**

**by Irwin Stambler,** Associate Editor

A RADICALLY NEW picture of aircraft design is taking shape at North American Aviation, Inc., Los Angeles Division, International Airport, Los Angeles 45, Calif., as USAF B-70 bomber nears completion. One major novelty, of course, is the shift in materials from aluminum alloys to steel and titanium. But an even more striking development is the use of sandwich construction for most of primary structure.

The B-70's wing skins, for example, are almost all PH15-7Mo steel honeycomb, NAA engineers told SPACE/AERONAUTICS. There are two main reasons for this. The very high thermal resistivity of honeycomb core makes it easier to withstand the high external temperatures in the high-Mach flight regimes. The honeycomb is also used as a thermal barrier to protect the fuel that fills most of the wing. If the fuel tanks used just a single skin, the 500-600-deg F outside temperatures could pass through easily and quickly heat the fuel to its boiling point. (The exact thermal resistivity of the NAA bomber's honeycomb structure depends on the density of the core and the type of bonding.)

The fuselage also makes wide use of PH15-7Mo steel, both in sandwich and sheet form. *Figure 1* shows a typical bulkhead honeycomb panel assembly. Depending on the design conditions, single-sheet construction or combined sheet core is used in different parts of the fuselage. The whole forward fuselage is of standard built-up construction and uses a lot of titanium (4-3-1 and 6Al-4V alloys). The engine ducting is of core construction (*Fig. 2*).

As *Figure 2* shows, the wing is multi-sparred and actually uses a great many spars. The leading and trailing edges are mainly of solid-core construction. For other wing areas, NAA made trade-off studies to decide whether to go to full-depth honeycomb or to honeycomb-skin-and-spar construction. Except for the leading and trailing edges, most of the wing uses the latter construction.

The typical wing section is of diamond shape and has the internal design shown in *Figure 2*. However, the actual wing varies from the idealized diamond shown in *Figure 2*; for instance, the leading edge is canted in some areas, and so on. The leading-edge core is either welded or mechanically attached, depending on whether access is required or not. For mechanical attachment, high strength blind rivets are used.

The wing core skin panels are welded together by methods like the two- and three-weld joints in *Figure 5*. The spar webs may be beaded, double-beaded, or honeycomb, depending on the loads. The heavy control surface fittings also carry the actuators, plumbing, etc. Some intercostal ribs are used to divide the fuel tank areas. The entire outer wing tip is hinged to fold down (*Fig. 2*). Because wing edges in many areas must be nearly razor-sharp, solid inserts in an arrow-

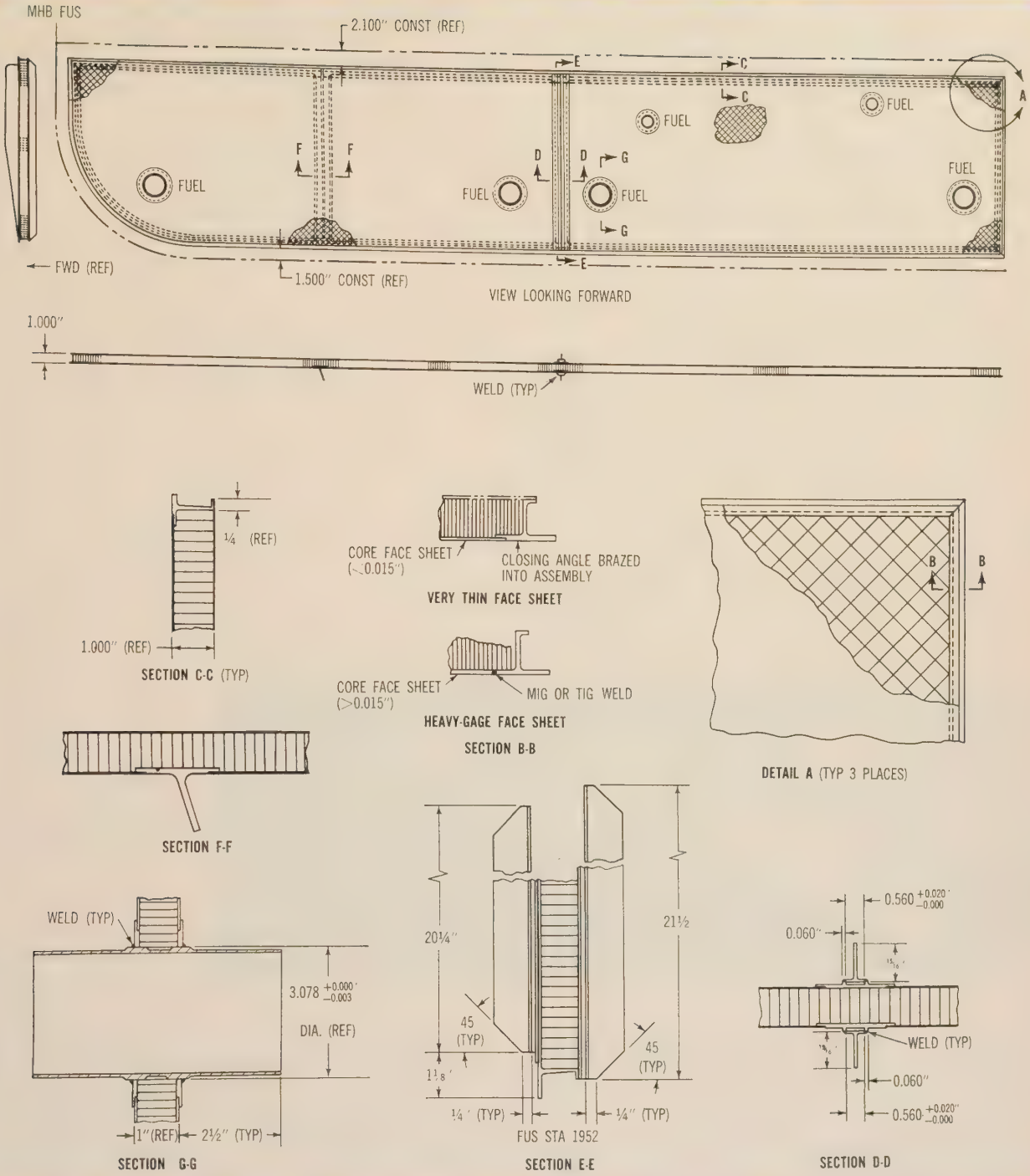


**FIGURE 1:** Typical B-70 honeycomb bulkhead panel assembly.

head or some other sectional shape are brazed into the core.

The fuselage skin panels in the wing area are also of PH15-7Mo sandwich construction. The wing is welded to the fuselage skin as shown in *Figure 2*. (The central part of the wing is partly supported by a truss arrangement from a shelf to the wing underside. In this way an open area is provided for the passage of bleed air.) A heavy attachment angle is integrally brazed into the wing stub core as shown in *Figure 5*. A similar setup is used for wing-to-upper-fuselage attachment. MIG or TIG fusion welding is used for this joint.*

A completely new approach was needed for the attachment angles, fittings, etc. NAA engineers point out, for instance, that, when brazed honeycomb is made with PH15-7Mo, a transformation growth results.

* "TIG" stands for "tungsten inert gas." A tungsten electrode creates the arc, into which the wire is fed; the wire is then melted into place. "MIG" stands for "metallic inert gas." Electric energy is used to melt both wire and some of the parent material in this case.

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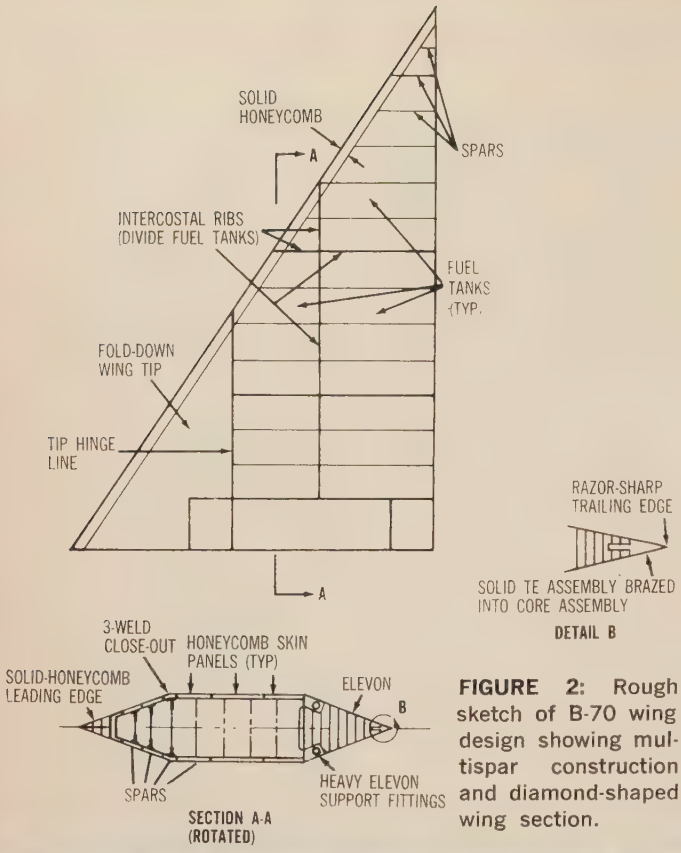
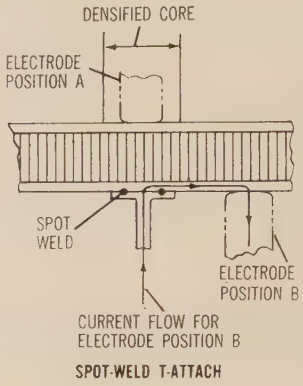
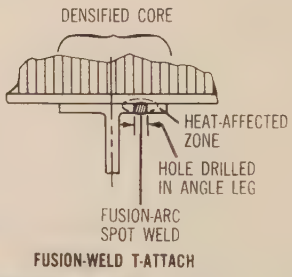
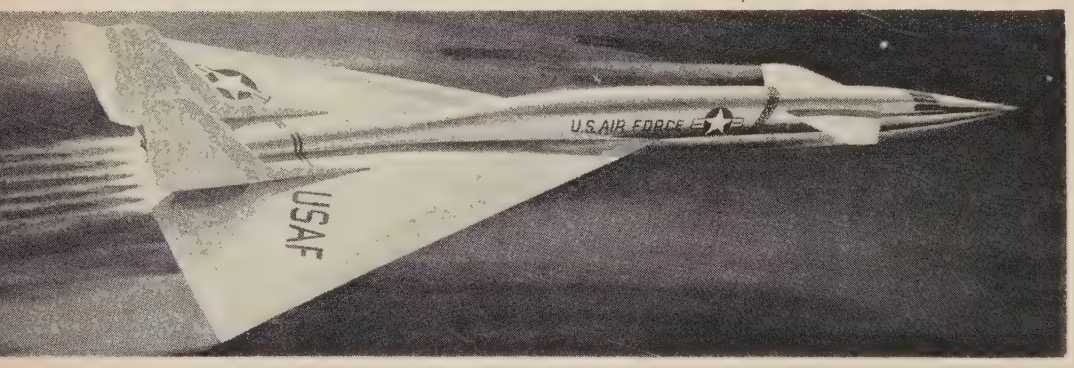



**FIGURE 2:** Rough sketch of B-70 wing design showing multispar construction and diamond-shaped wing section.

**FIGURE 3:** T-angle for spars, webs, etc., is attached to core panels by methods like these. In many cases, though, the tee is brazed integrally into the core.




**ARTIST'S** conception of Mach 3 B-70 bomber.

With integral internal attachment sections, therefore, it's hard to predict exactly where the angle will be after the sandwich has been fabricated. Besides, there's a variation of growth from one panel to another (because of the amount of cold work, braze conditions, etc.). Normally it amounts to about 0.0008 in./in.

For narrow core panels of eight feet or less, integral angles can be used, but for the larger sections, some of which are up to 20 ft wide, they can't, and post-braze attachment of connecting sections is needed.

There are many ways to attach angles to the core, such as two possibilities shown in *Figure 3*. Conventional spot-welding techniques can be used, if the anode is in either position A or B in *Figure 3*. For thin core, it's preferable to have the anode alongside the angle—if it is in position B, current might flow through the thin core and deform it.

Arc spot-weld can also be used—a hole is drilled in the angle, and weld material is inserted to provide a fusion weld. This method has the advantage of not requiring pressure for the weld; its disadvantage is that it produces a heat-affected zone with reduced PH15-7MO properties. Still another possibility is to have a land on the face sheet and fusion-weld the angle into position. But again this approach results in a non-heat-treat area and additional material must be used to make up for the loss in properties.

## Densified core used in attach area

As *Figures 3 & 5* show, densified core is required in areas where attachment angles are installed. In a typical case, a core of 20 lb/cu ft is used. (The normal core density is eight lb/cu ft.)

Panel joints are usually made by TIG or MIG welding. For the two-weld joint of *Figure 4*, pads must be provided on the core face sheets that are about two and a half or three times thicker than the original sheet and take the loads across the non-heat-treat area resulting from the weld. In addition, the core is

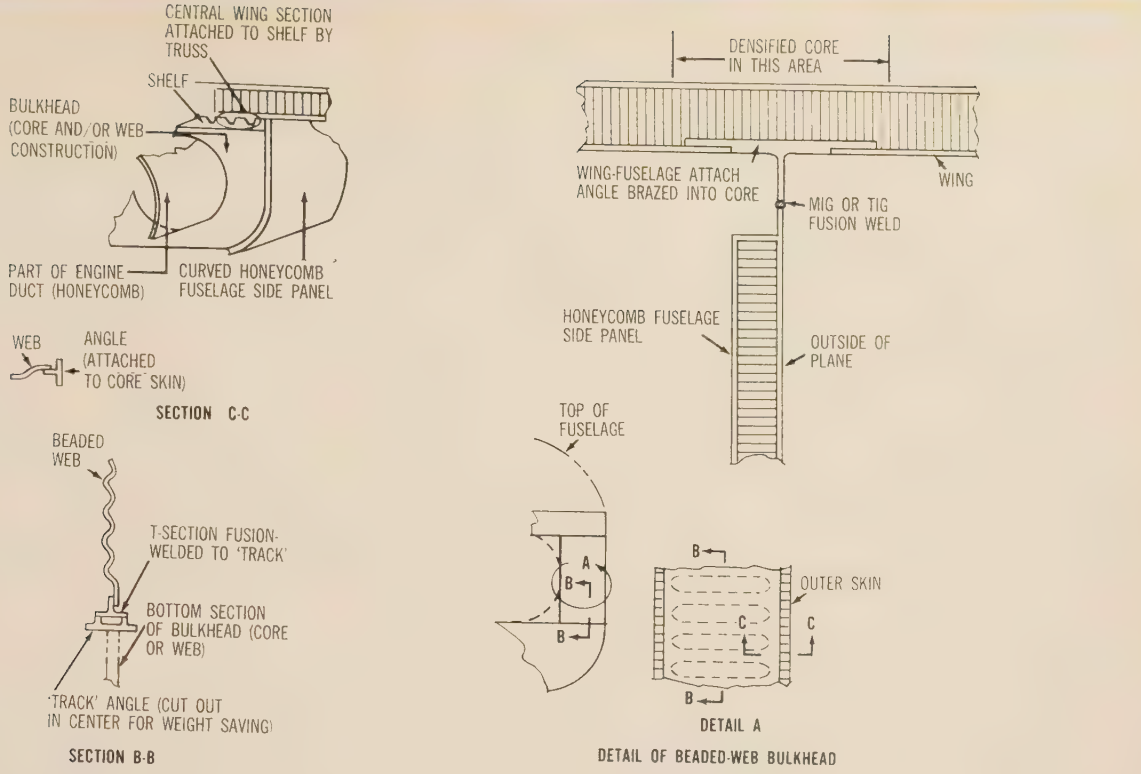



**FIGURE 4:** Wing-to-fuselage honeycomb attach and typical web-type bulkhead panel assembly.

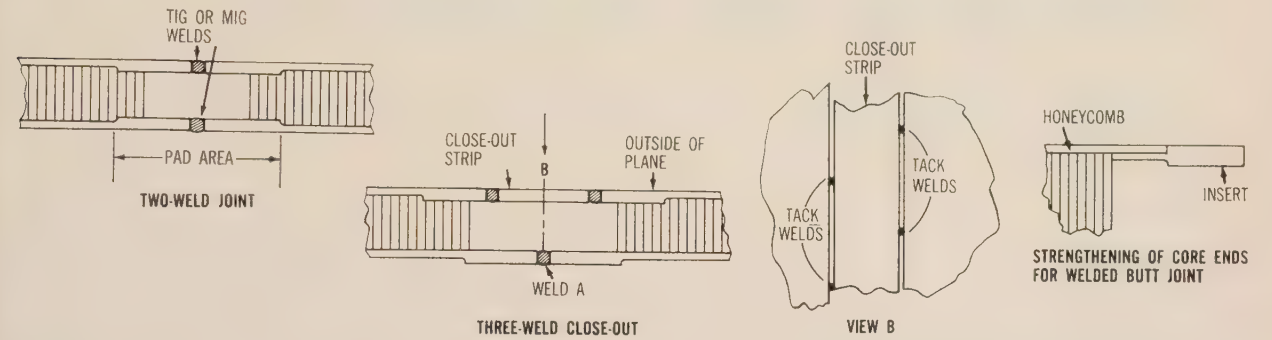



**FIGURE 5:** Honeycomb panel assembly methods used on the B-70 include two-weld joints and three-weld close-cuts. In case heavier-gage material is needed at a joint, an insert is brazed into the core (bottom).

cut back for a certain distance on both sides of the weld to leave a narrow area for inserting a strip of X-ray film for weld analysis (and to keep the weld heat from debrazing the core in this region).

For a three-weld closeout joint (*Fig. 4*), the torch is first brought in to make weld A. A narrow close-out strip is then lightly tack-welded into place, and the other two welds are made. Very careful control is required throughout design and production to take care of the problem of shrinkage (particularly on close-out joints). For instance, some shrinkage results when weld A is completed and still more when the second weld is finished.

When the final weld is made, certain lock-in stresses result that must be kept to a minimum by proper choice of tooling. Special chill bars, different types of backup gases, and prechilled joints are some of the expedients used by NAA. Heavy copper chill bars, for example, are placed right alongside the joint during welding to quickly conduct away heat.

For bulkhead closing angle design (*Fig. 1*), it's desirable (where face sheet thickness permits it) to use a butt joint weld to attach the angle to the sandwich before brazing. After this has been done, core and top sheet are inserted, and the assembly is brazed. Prebraze welding avoids the need for adding weight to the angle, since you end up with a heat-treated joint. You also save weight by not using the braze compound (which is mostly silver). However, with face sheet thicknesses of less than 0.015 in. it's hard to get the core to lie flat enough for a butt joint weld. NAA therefore uses a lap braze joint angle attach in these cases.

Weight saving, of course, is more important on the B-70 than ever before. For instance, 0.006-in. face sheet (rolled to 26½ in. in width) can be bought to tolerances of ±0.0006 in. However, if you get +0.0006 in. throughout the plane, you have added 2000 lb to the craft. As a result, either special rolling processes are needed or you must measure thickness very closely and belt-sand to size.—End

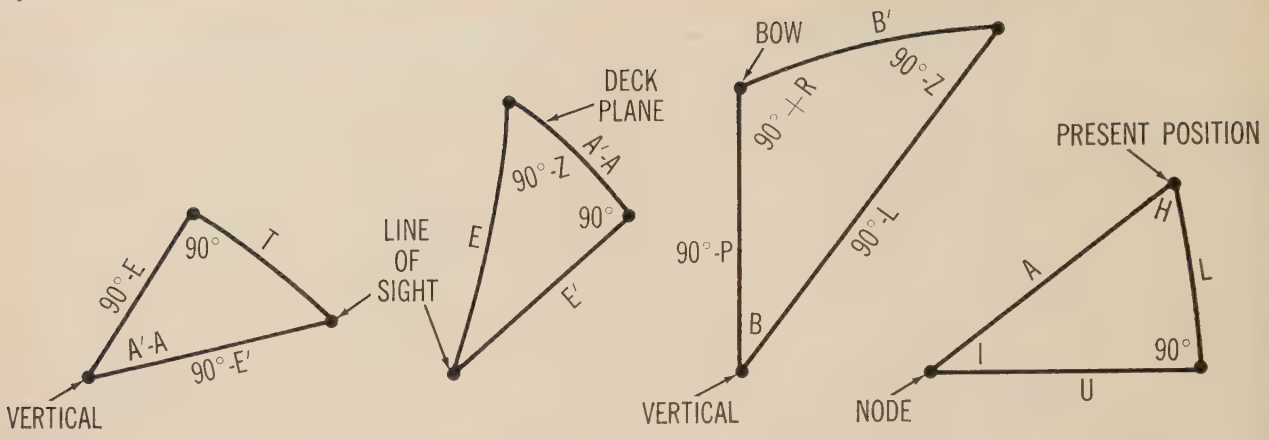



**FIGURE 1:** Projection of typical spherical triangles containing all given and unknown angles and used to solve the problems given in Figures 13-17 in the first article in this series (May 1960, p. 59).

# Solving 3-D problems

## made simple by stereographic projection—II

**This is the second and last article in a series on solving three-dimensional problems by stereographic projection. It shows how to apply this method to actual design problems.**

**by Sidney Godet,** Director, Engineering Research, Reeves Instrument Corp.[1]

TO SOLVE dynamic three-dimensional problems by stereographic projection, little more than the basics of plane geometry and trigonometry are needed. Essentially you begin with the problem laid out on a sphere. You then project points on the surface of the sphere onto a planar surface so that (visually, at least) the three-dimensional problem is reduced to two dimensions for manipulation and analysis.

Once you know what you are doing, you can get an approximate solution of a complex problem in a matter of minutes by just sketching in construction lines. If you want to go to the trouble of using compass, ruler, and protractor, you can measure off angles more accurately, and calculate arc lengths from them: You locate the pole of the circle, construct circles between the pole and the end points of the arc, and measure the angle between the two circles at the pole.

For a precise mathematical solution, you often can choose a single spherical triangle that contains all the given and unknown angles of your problem (*Fig. 1*). Now for any spherical triangle for which three of the six angles are known, the other three may be found. Also, if any three known quantities of a spherical triangle are consecutive—two sides, and an included angle or two angles and an included side—a solution is always possible and will be unique. For other combinations of knowns and unknowns, you may get no solution, two solutions, or an indeterminate solution. Obviously you should make every attempt to choose a triangle with consecutive known quantities.

Assume a spherical triangle for which two sides and the included angle (*b, A, c*) are given and the unknowns *B* and *a* are to be found.[2] To simplify the mathematical

(1) Reeves Instrument Corp. Roosevelt Field, Garden City, N. Y.

(2) In the accepted notation for spherical triangles, a lower-case letter

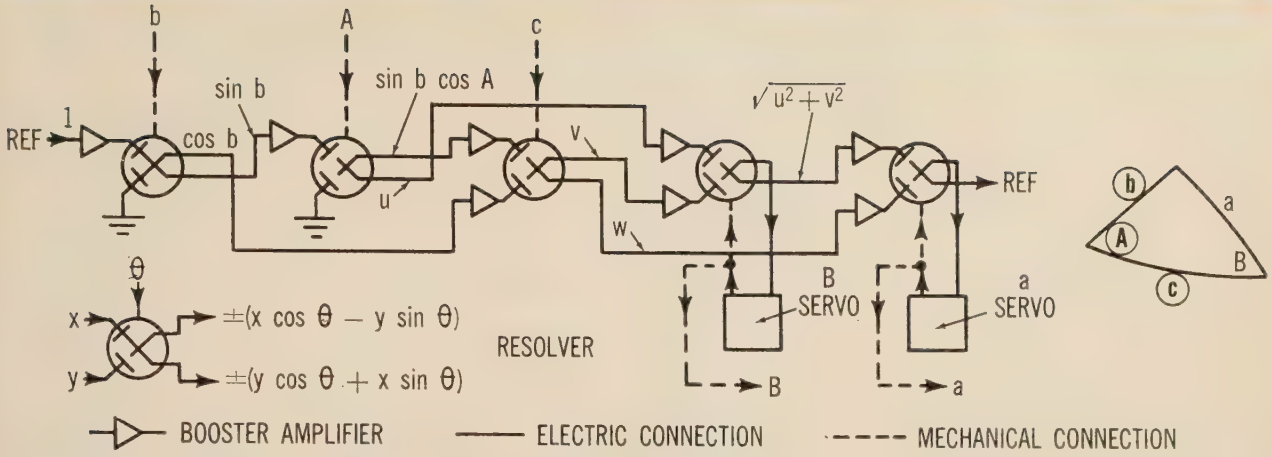



**FIGURE 2:** Analog computer solution of a spherical triangle.

relationships, we use a set of components of a unit vector *(u, v,* and *w),* which are defined as:

$$u = \sin b \sin A,\ v = \cos b \sin c + \sin b \cos A \cos c,$$
$$w = \cos b \cos c + \sin b \cos A \sin c.$$

From this you get:

$$\tan B = u/v,\ \tan a = \sqrt{u^2 + v^2}/w,$$
$$u^2 + v^2 + w^2 = 1.$$

These formulas give you solutions for the unknowns *B* and *a.* By substituting *C* for *B* and interchanging *b* and *c,* you can next solve for the angle *C,* which is the third unknown.

A solution is always possible and unique, for the answer for any unknown angle is always given in terms of the tangent of the angle. By choosing the positive root of the radical $\sqrt{u^2 + v^2}$, you restrict *a* to values between zero and 180 degrees. When you go from one point on a sphere to another via a great circle, therefore, you always go by the shortest path.

There is another advantage to determining unknown angles by their tangents. You don't get involved in hairy computations—as you do, for instance, when you try to determine an angle around 90 deg from its sin alone.

The quantities *u, v,* and *w* are derived by successive resolutions involving *b, A,* and *c:*

- Resolve unity through angle *b* to find *cos b* and *sin b.*
- Resolve *sin b* through angle *A* to get *sin b cos A* and the *sin b sin A,* which is the value of *u.*
- Resolve *cos b* and *sin b cos A* through angle *c* to find *w* and *v:*

$$\cos b \cos c + \sin b \cos A \sin c = w,$$
$$\cos B \sin c - \sin b \cos A \cos c = v.$$

## Quantities put in consecutive order

In effect, we have put the five quantities involved in the formulas in consecutive order (as must be done in all problems of this type):

$$b \rightarrow A \rightarrow c \rightarrow B \rightarrow a.$$

The first three quantities are known and the last two unknown. We found the two unknowns in sequence by resolving a unit vector through the three known angles in sequence.

When two angles and the included side *(B, a, C)* of a spherical triangle are given, we define a new set of components as:

$$u = \sin B \sin a,\ v = \cos B \sin C + \sin B \cos a \cos C,$$
$$w = \sin B \cos a \sin C - \cos B \cos C.$$

In this case:

$$\tan b = u/v,\ \tan A = \sqrt{u^2 + v^2}/w,$$
$$u^2 + v^2 + w^2 = 1.$$

Analyze these formulas and you will soon come to pretty much the same conclusions as we did for the first set of formulas. In this case, *A* is arbitrarily limited to a value between zero and 180 degree.

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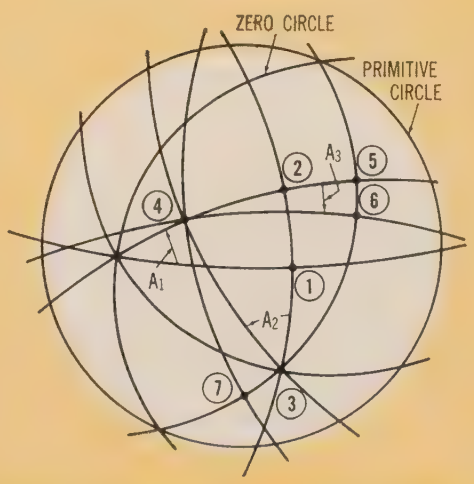


**FIGURE 3:** Method of successive resolutions.

represents a side and an upper-case letter an angle. (A distinction is made even though sides frequently are referred to and measured in terms of angles.) The same letter is used for a side and the angle opposite to it.

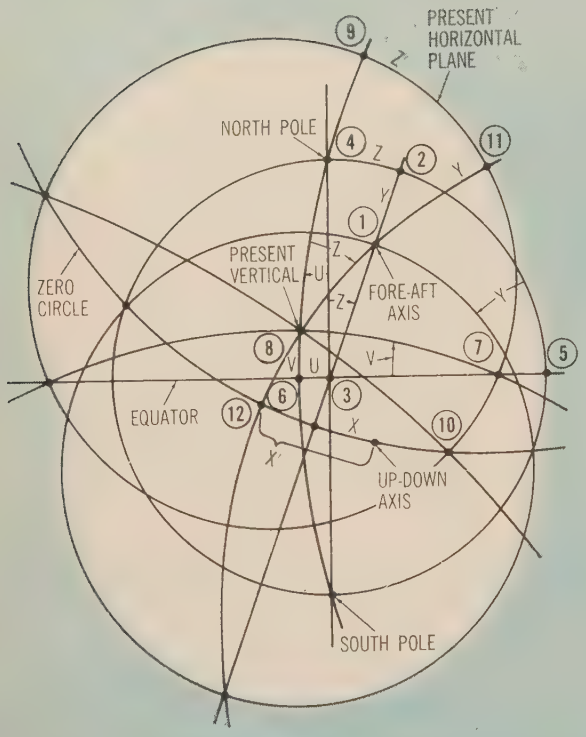


**FIGURE 4:** First chain in series of successive resolutions, used to find the unknowns Y′ and Z′.

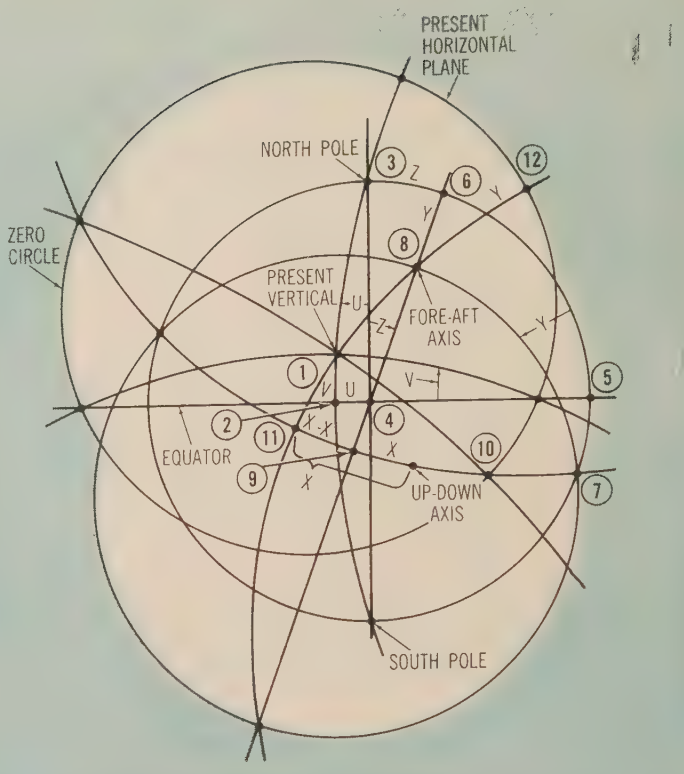


**FIGURE 5:** Second chain in series of successive resolutions, used to find the X′, the third unknown.

You can solve for $u$, $v$, and $w$ by successive resolutions of a unit vector about $B$, $a$, and $C$ finding first $b$ and then $A$. In consecutive form, the problem runs:

$$B \rightarrow a \rightarrow C \rightarrow b \rightarrow A,$$

much the same as the first problem.

Each problem shows that, if you know any three consecutive quantities of a spherical triangle, we can solve for the next two quantities in the same sequence through a series of consecutive resolutions. In the special case involving an angle or side equal to 90 deg, the value of sin or cos 90 deg (1 or 0) may be substituted in the general formulas.

## Analog computer gives same answers

The same answers that we have just found by trigonometric solution can also be given by an analog computer (*Fig. 2*). The solution is most easily mechanized if you use induction resolvers, which operate with ac inputs and outputs. Other mechanisms like potentiometer-type dc resolvers and electronic function generators can also be used, provided their outputs are equivalent to those of an induction resolver.

Each resolver has two electric inputs ($x$ and $y$). The mechanical shaft is driven through some angle with respect to a reference position. If this mechanical rotation is $\theta$, then the two electric outputs of each resolver are $x \cos \theta - y \sin \theta$ and $y \cos \theta + x \sin \theta$. You can get outputs of either polarity, depending on which end of a given output winding is grounded. In this way, each of the resolutions we have just gone through can be mechanized by a single resolver, driven mechanically by the shaft, which represents the angle involved in the problem.

What happens when you cannot have a single spherical triangle that contains all the given and unknown angles? For these more complicated cases, let's try a brute-force approach.

You can first solve some specific triangle with three known parts and then use the results together with other known parts to solve a second spherical triangle. You may have to go through this process several times before you have found all the unknowns.

A note of warning: use a large sheet of paper and write small—the first time around you will find rather complicated terms cropping up at intermediate points. But if you manipulate these terms properly, you'll find that most of them drop out.

## Relearn trigonometric identities

Reducing the final terms to their simplest form is worth the effort of relearning your trigonometric identities. These you must have down pat, for the equivalence of terms is not at all apparent in a string of complicated expressions.

An analog computer can be used to mechanize this brute-force method, too. Servos are made to generate the intermediate angles of the given expression and resolvers on the servo shafts the new intermediate angles.

Now when you look carefully at this mechanization, you discover that you are using only the sines and cosines of the new intermediate angles. And to get these intermediate angles, you started with the sine and cosine of the original angle (to generate the servo shaft rotation).

## No new information has to be found

What does this mean? Simply that none of the information you need for the solution has to be found—it's all there right at the start. So why generate the intermediate angles as shaft rotations? By careful analysis, you should be able to reduce the computer mechanization to the point where:

- every known angle is represented by an input shaft containing one or more resolvers,
- every unknown angle requires only one servo containing one or more resolvers,
- no intermediate servos are needed.

Now, why don't we develop a solution for complex problems in which trigonometric manipulations play no part? There is a method of successive resolutions that enables us to do just that. Its basic concept is that, if a unit vector is chosen in any given direction, then the component of this vector at any point 90 deg away from the chosen direction will be zero.

The trick is to choose a direction that will let you successively resolve the unit vector through all the known angles of the problem (exactly as in solving spherical triangles). After that, you can resolve the vector through one or more of the unknown angles. Eventually one of the components will fall in a direction 90 deg away from the originally chosen unit vector. When this happens, you can equate the analytical expression containing the unknown angle (or angles) to zero and solve for the unknown.

The general procedure for applying the method of successive resolutions to a stereographic projection is (*Fig. 3*):

- Choose a direction for the unit vector, which is a point on the projection, and label this point *1*. The circle whose pole is this point then becomes the "zero" circle. Sooner or later, one of the resolved components must lie on this circle.
- Resolve the unit vector *(1)* into two components (*2* and *3*) by resolving through $A_1$, one of the known angles. Since the apex of $A_1$ must be 90 deg from *1*, components *2* and *3* will be represented by points lying on a circle whose pole is the apex of $A_1$. This circle will also pass through *1*. Point *3* is the apex of the next known angle $(A_2)$.
- Resolve *2* through $A_2$ to get components *4* and *5*. Points *2*, *4*, and *5* then lie on a circle whose pole is *3*. Components *3*, *4*, and *5* now form an orthogonal set (each is 90 deg away from the other two). Point *4* is the apex of the next known angle $(A_3)$.
- Resolve *3* and *5* through $A_3$ to get components *6* and *7*. Points *3*, *5*, *6*, and *7* then lie on a circle whose

*more on next page*

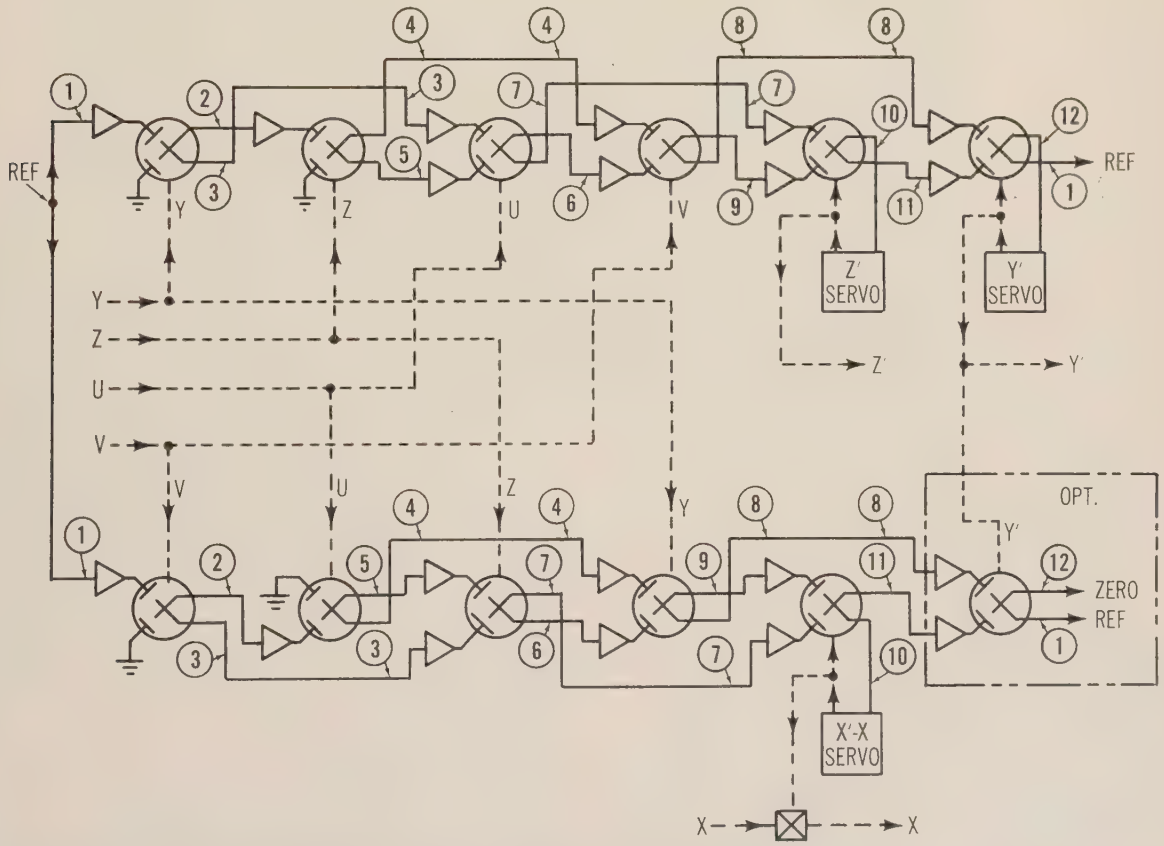


**FIGURE 6:** Computer mechanization to find unknowns X', Y', and Z'.

pole is *4*. Components *4*, *6*, and *7* now form an orthogonal set.

• Continue this process through all the known angles and through one or more of the unknown angles. Keep an orthogonal set of components at each intermediate step until one of the components falls on the "zero" circle.

Unfortunately, there are no hard and fast rules to tell you in which direction to choose the unit vector—you'll have to learn by experience. In general, though, the unit vector should be chosen along one of the principal axes of the problem (the fore-aft axis of a vehicle, vertical, North, etc.).

Usually a single process of successive resolutions yields a solution for no more than two unknown angles. For additional unknown angles, you have to start out with a new unit-vector location and repeat the process.

If the problem is to be mechanized on an analog computer, then each successive resolution must be represented by a resolver driven by the given or unknown angle through which you make the resolution. Quantities equated to zero become inputs to the servo amplifiers driving the unknown quantities.

## Finding aircraft attitude angles

To see how both graphic and computer solutions work, assume you have an aircraft carrying an inertial stabilization system. Once aligned with respect to some inertial coordinates, this system maintains its orientation indefinitely. The aircraft starts out at the equator with the inertial system aligned so that one axis is vertical and another points to true north. The roll, pitch, and heading angles *(X, Y, Z)* with respect to the gimbaled inertial system are picked off as given angles of the problem.

Its own motion and that of the earth carry the aircraft away from the initial reference point by a longitudinal angle $U$ and a latitude angle $V$, which are also given. The problem is to find the roll, pitch, and heading angles referred to the present position of the aircraft *(X′, Y′, Z′)*. Compute the value of these angles from the five given angles *(X, Y, Z, U, V)* by successive resolution of vectors (*Fig. 4*):

• Choose the unit vector **1** along the fore-aft axis of the aircraft. Draw in the zero circle (90 deg from **1**).

• Resolve **1** through $Y$ to get components **2** and **3**:

$$\mathbf{2} = \cos Y,\ \mathbf{3} = \sin Y.$$

• Resolve **2** through $Z$ to get **4** and **5**:

$$\mathbf{4} = \mathbf{2}\cos Z,\ \mathbf{5} = \mathbf{2}\sin Z.$$

Components **3**, **4**, and **5** form an orthogonal set.

• Resolve **3** and **5** through $U$ to get **6** and **7**:

$$\mathbf{7} = \mathbf{5}\cos U + \mathbf{3}\sin U,\ \mathbf{6} = \mathbf{3}\cos U - \mathbf{5}\sin U.$$

Components **4**, **6**, and **7** form an orthogonal set.

• Resolve **4** and **6** through $V$ to get **8** and **9**:

$$\mathbf{8} = \mathbf{6}\cos V + \mathbf{4}\sin V,\ \mathbf{9} = \mathbf{4}\cos V - \mathbf{6}\sin V.$$

Components **7**, **8**, and **9** form an orthogonal set.

• Resolve **7** and **9** through $Z'$ to get **10** and **11**:

$$\mathbf{11} = \mathbf{9}\cos Z' + \mathbf{7}\sin Z',\ \mathbf{10} = \mathbf{7}\cos Z' - \mathbf{9}\sin Z'.$$

Component **10** is on the zero circle and therefore equals zero. Components **8**, **10**, and **11** form an orthogonal set.

• Resolve **8** and **11** through $Y'$ to get **1** and **12**:

$$\mathbf{1} = \mathbf{11}\cos Y' + \mathbf{8}\sin Y',\ \mathbf{12} = \mathbf{8}\cos Y' - \mathbf{11}\sin Y'.$$

Component **12** is on the zero circle and therefore equals zero. Component **1** is in the same direction as the original unit vector and therefore equals unity. Components **1**, **10**, and **12** form an orthogonal set.

Now that you know that **10** and **12** equal zero, you can solve for the unknowns $Z'$ and $Y'$.

## New unit vector direction for X′

The roll angles $X$ and $X'$ have not appeared so far. To find $X'$, you must start all over with a unit vector in a new direction (*Fig. 5*):

• Choose the unit vector **1** along the present vertical direction. Draw in the zero circle (90 deg from **1**).

• Resolve **1** through $V$, to get **2** and **3**:

$$\mathbf{2} = \cos v,\ \mathbf{3} = \sin V.$$

• Resolve **2** through $U$ to get **4** and **5**:

$$\mathbf{4} = \mathbf{2}\cos U,\ \mathbf{5} = -\mathbf{2}\sin U.$$

Components **3**, **4**, and **5** form an orthogonal set.

• Resolve **3** and **5** through $Z$ to get **6** and **7**:

$$\mathbf{6} = \mathbf{3}\cos Z + \mathbf{5}\sin Z,\ \mathbf{7} = \mathbf{5}\cos Z - \mathbf{3}\sin Z.$$

Components **4**, **6**, and **7** form an orthogonal set.

• Resolve **4** and **6** through $Y$ to get **8** and **9**:

$$\mathbf{8} = \mathbf{6}\cos Y + \mathbf{4}\sin Y,\ \mathbf{9} = \mathbf{4}\cos Y - \mathbf{6}\sin Y.$$

Components **7**, **8**, and **9** form an orthogonal set.

• Resolve **7** and **9** through $X' - X$ to get **10** and **11**:

$$\mathbf{10} = \mathbf{7}\cos(X' - X) + \mathbf{9}\sin(X' - X),$$
$$\mathbf{11} = \mathbf{9}\cos(X' - X) - \mathbf{7}\sin(X' - X).$$

Component **10** is on the zero circle and therefore equals zero. Components **8**, **10**, and **11** form an orthogonal set.

Now that you can set $\mathbf{10} = 0$, you can solve for $X' - X$ to find the last of the unknowns in the problem.

You can get an alternate solution for $Y'$ by resolving **8** and **11** through $Y'$ to get **1** and **12**:

$$\mathbf{1} = \mathbf{11}\cos Y' + \mathbf{8}\sin Y',\ \mathbf{12} = \mathbf{8}\cos Y' - \mathbf{11}\sin Y'.$$

Component **12** is on the zero circle and therefore equals zero. Component **1** is in the same direction as the original vector and is therefore equal to unity. Components **1**, **10**, and **12** form an orthogonal set.

## Accuracy of computer can be checked

You can get the same answers on an analog computer, using a separate resolver for each resolution (*Fig. 6*). When you are finished, you can check the operational accuracy of the computer by regenerating the unit vector—you should get a voltage equal to the original reference voltage.

Components **1** and **12** of the second chain of resolutions may be generated from the values of $Y'$ computed in the first chain. These values should be unity and zero, respectively. They can also be used for a further check of the operation of the computer.

If you look back over the order of the known quantities in the second chain *(V, U, Z, Y)*, you see that it is precisely the reverse of the order in the first chain *(Y, Z, U, V)*. This generally turns out to be the case whenever you have to use two different chains. Therefore the order of resolutions can serve as a clue to the proper location of the second unit vector.—End

**Reprints** of the articles on stereographic projection (including last month's article) will be available in limited quantities to fill single-copy and small-lot orders. For bulk orders, prices will be quoted. In either case, please address Reprint Dept., SPACE/AERONAUTICS, 205 E. 42nd St., New York 17, N. Y. Reprint requests probably will be filled in August.

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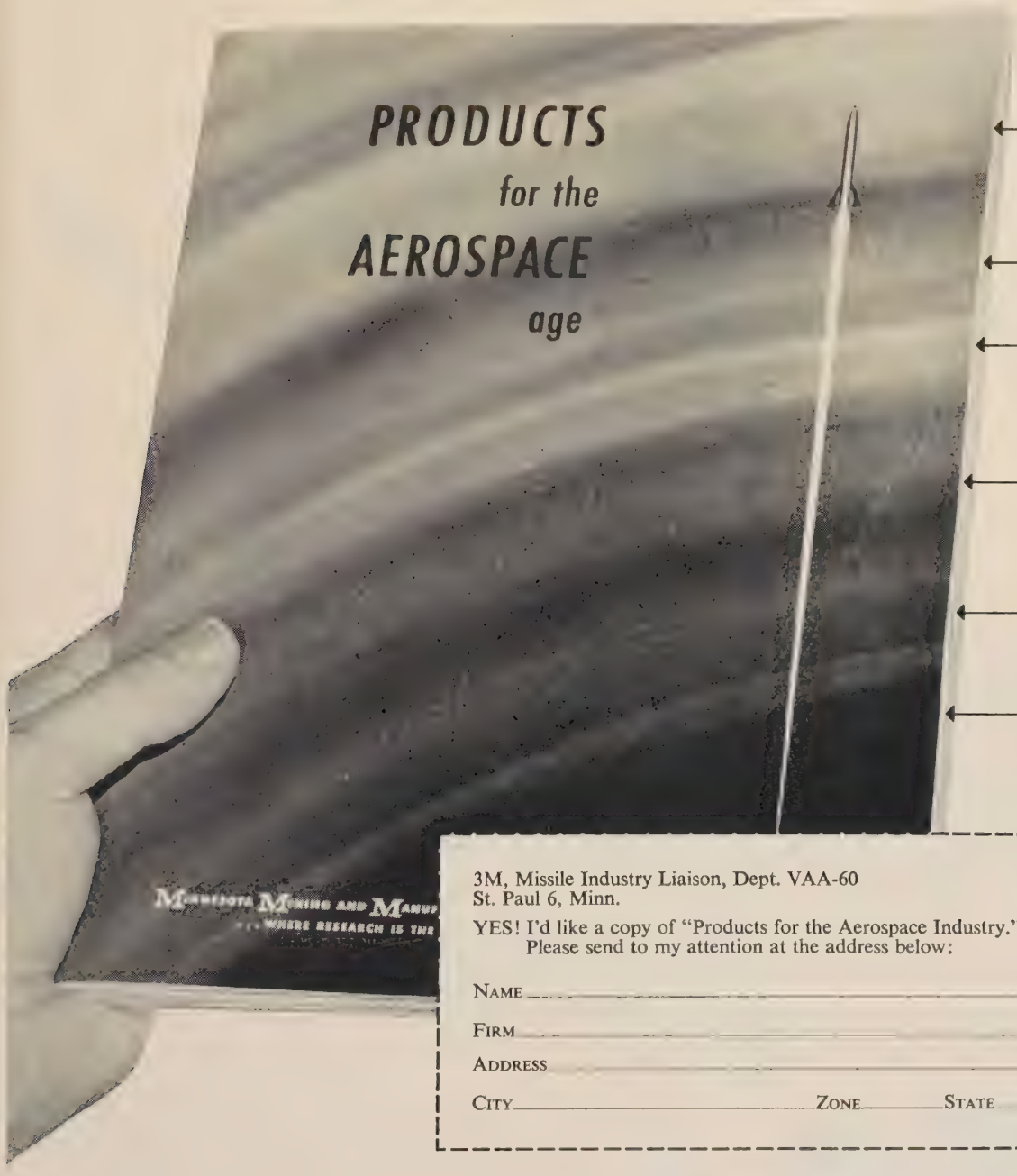
Write for your copy today! You'll find it a materials reference worth keeping and a source of new ideas, too!

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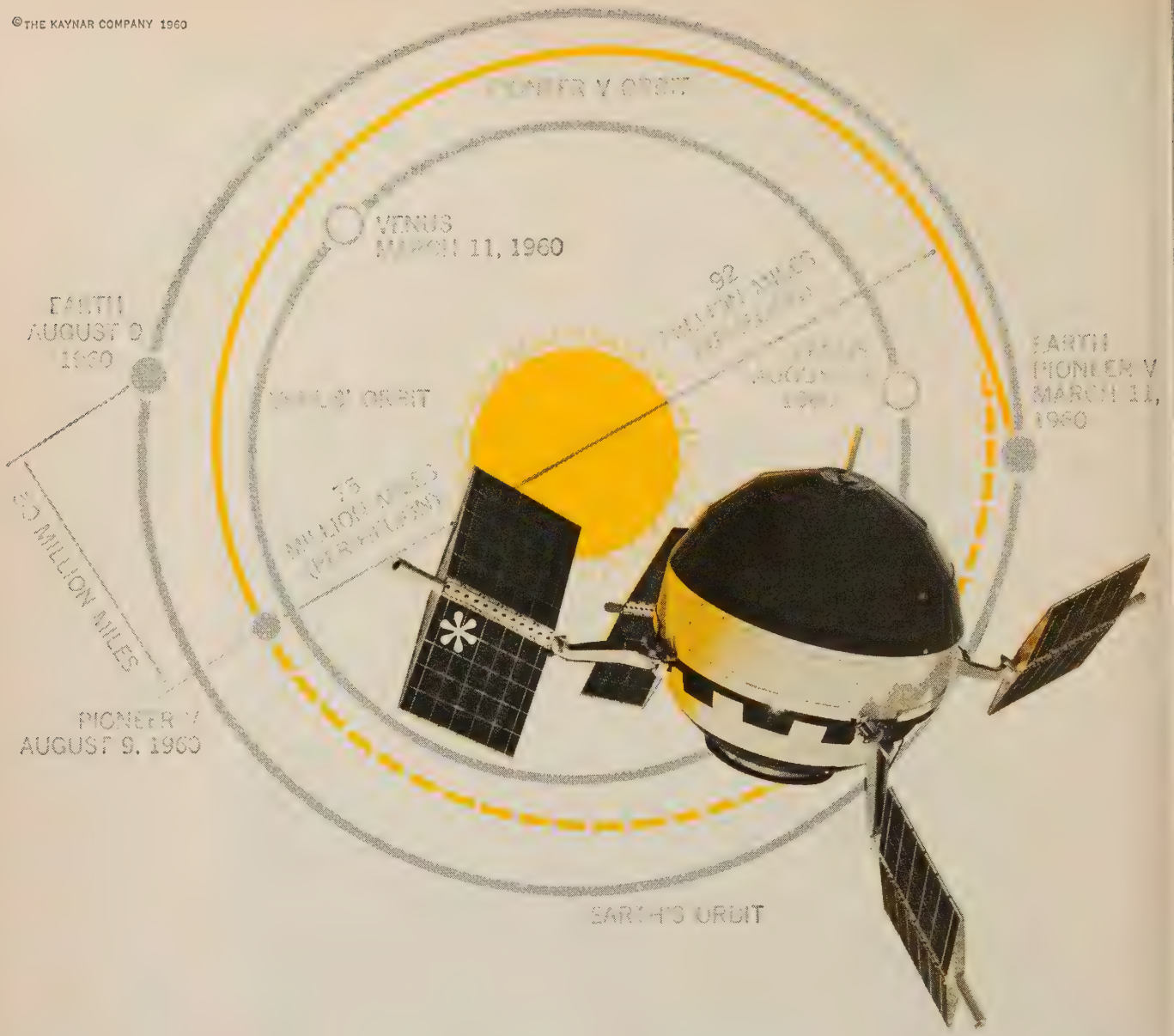
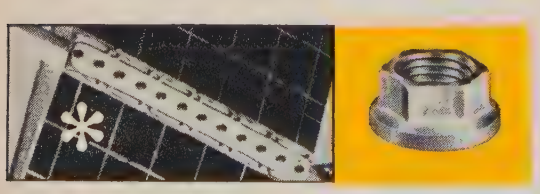



# KAYLOCK® NUTS BOOST PIONEER V PAYLOAD

*From one pioneer to another – congratulations! Kaylock,® pioneer in lightweight, self-locking nuts, salutes Space Technology Laboratories for achieving the world's deepest space probe with Pioneer V. Kaylock nuts are used throughout the 95-pound, 26-inch " inter-planetary space laboratory, " which on July 19 will have catapulted more than 50 million miles from earth. On August 9, Pioneer V will penetrate closer to the sun than man has ever come before, and will approach the orbit Venus makes around the sun. This is the maximum range at which communication with earth is now deemed possible.*

*Selected for their high quality, reliability and space-saving advantages the Kaylock miniature nuts used on Pioneer V help boost the payload-carrying capacity of the compact, highly-instrumented planetoid. Kaylock's engineering and production departments are proud to have supplied vital fastener components for this noteworthy step in space exploration.*



Kaylock nuts are plainly visible on the Pioneer V's four solar-cell paddles, which convert solar energy to electricity. Kaylock nuts also are used in many other parts of the space planetoid.

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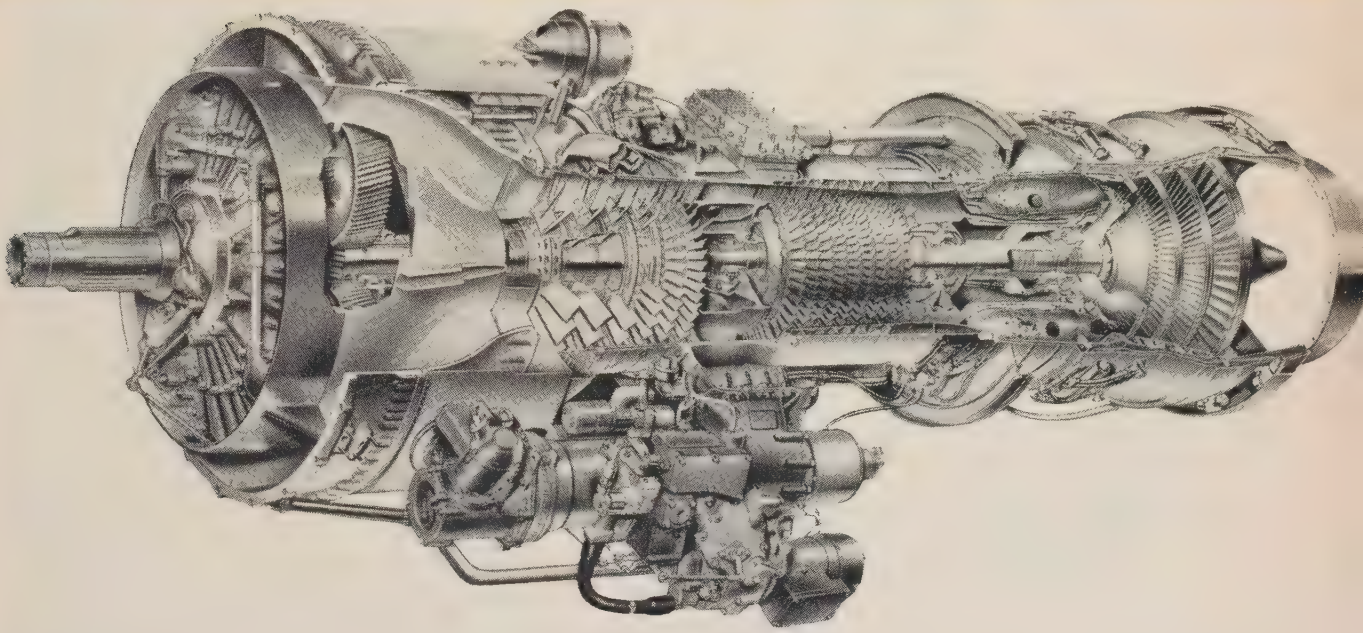
# Tyne turboprop

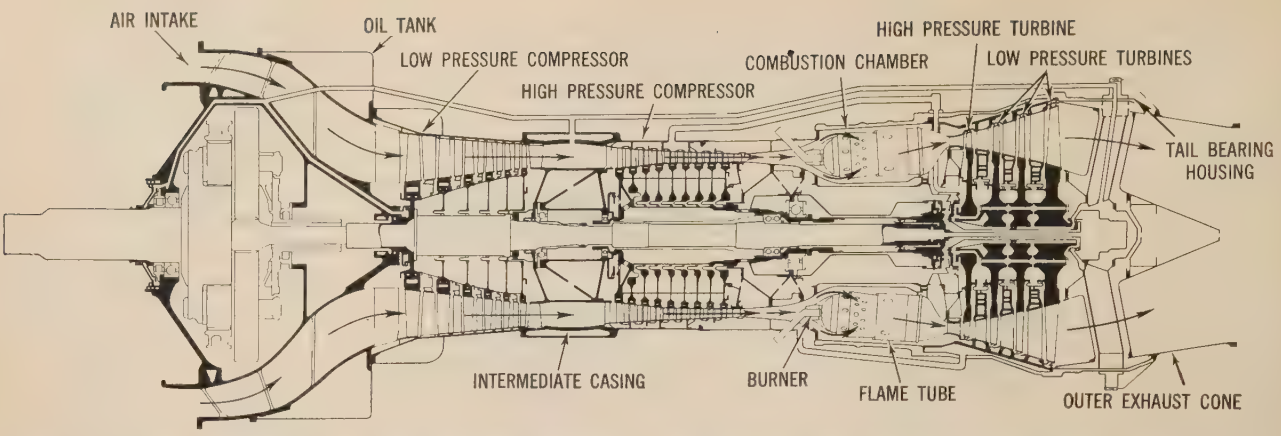
## designed for low weight, compactness, fuel economy

**by Randolph Hawthorne,** Editor

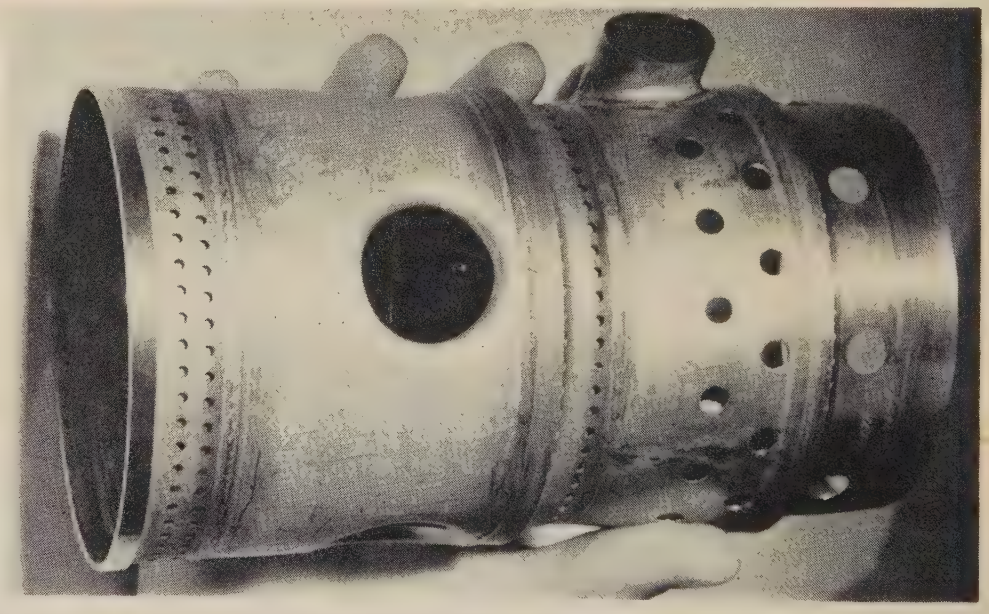
DESIGNED for the second generation of turboprop transports, the Tyne combines high power ratings with low weight, compact installation and very low specific fuel consumption. Low sfc and specific weight are achieved mainly through a high pressure ratio (13:1) and a high flame temperature, made possible in turn by air-cooled turbine blading and twin-spool axial compressors. The Tyne draws extensively on earlier design experience at Rolls-Royce Ltd., Aero Engine Div., P. O. Box 31, Derby, England. The compressors, for instance, are partly scaled from Conway compressors, the combustion system resembles the one in the Avon and Conway, intake de-icing is based on methods used in the Dart, and the turbine blades have extended roots, as do those in the Avon, Dart, and Conway, to lower the disk rim temperature. Three Tyne models are in production. Write in No. 57 on Reader Service card for more information.



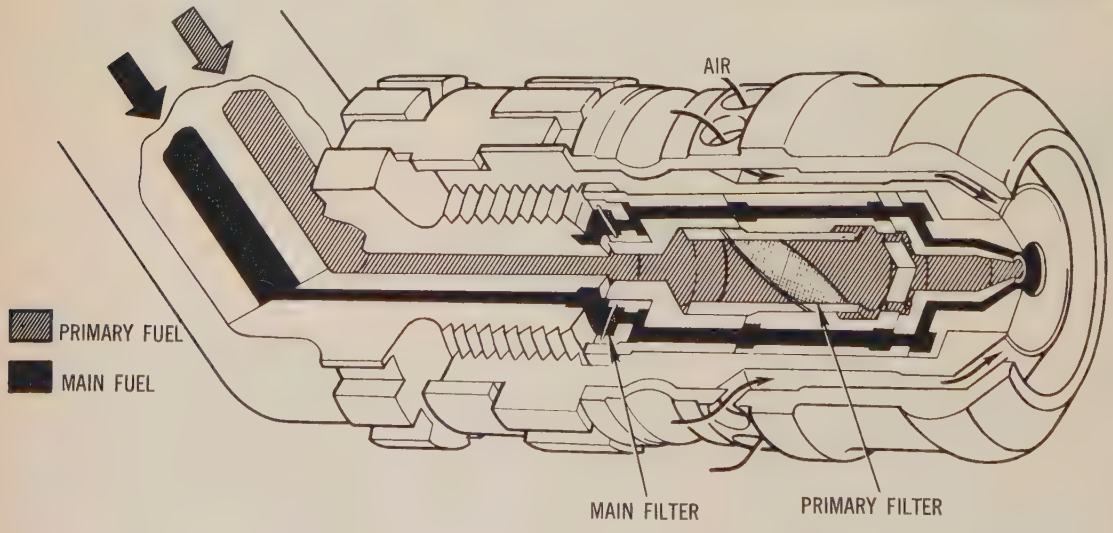
**MAIN FEATURES** of Tyne include a six-stage, low pressure, axial flow compressor coupled to a three-stage, high pressure axial turbine; a nine-stage high pressure axial compressor coupled to single-stage turbine, and an annular combustion chamber housing 10 straight-flow flame tubes. The combined compressor pressure ratio is 13-5:1. Both shafts and the prop turn counter-clockwise viewed from aft. The magnesium air intake is on the front face of the steel low pressure compressor casing, forming an annular casing enclosing the prop reduction gear. An annular steel oil tank nearly surrounds the air intake. Engine power control is by a lever mechanically connected to the fuel control unit, the prop controller, and a manual fuel trimmer.




**MAIN PARTS** and gas flow of the Tyne. The intermediate aluminum compressor casing, which is bolted to the rear face of the low pressure compressor casing, carries two wheelcases. Each of these is driven by one of the engine shafts. The wheel case driven by the low pressure shaft mounts the hydromechanical speed governor and tachometer for this shaft and also the auxiliary gearbox drive flange. The wheel case driven by the high pressure shaft carries a starter motor, a fuel control unit, a fuel pump, a horsepower tachometer, and shaft brake.

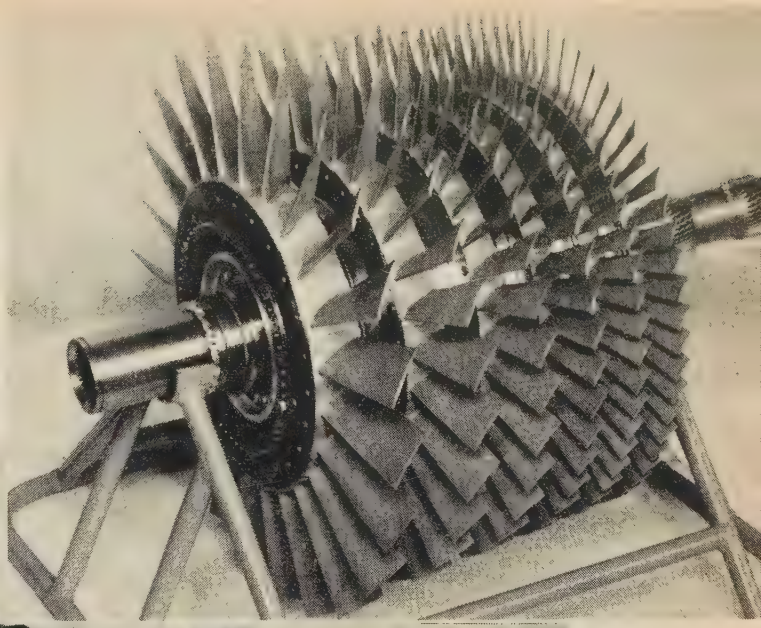


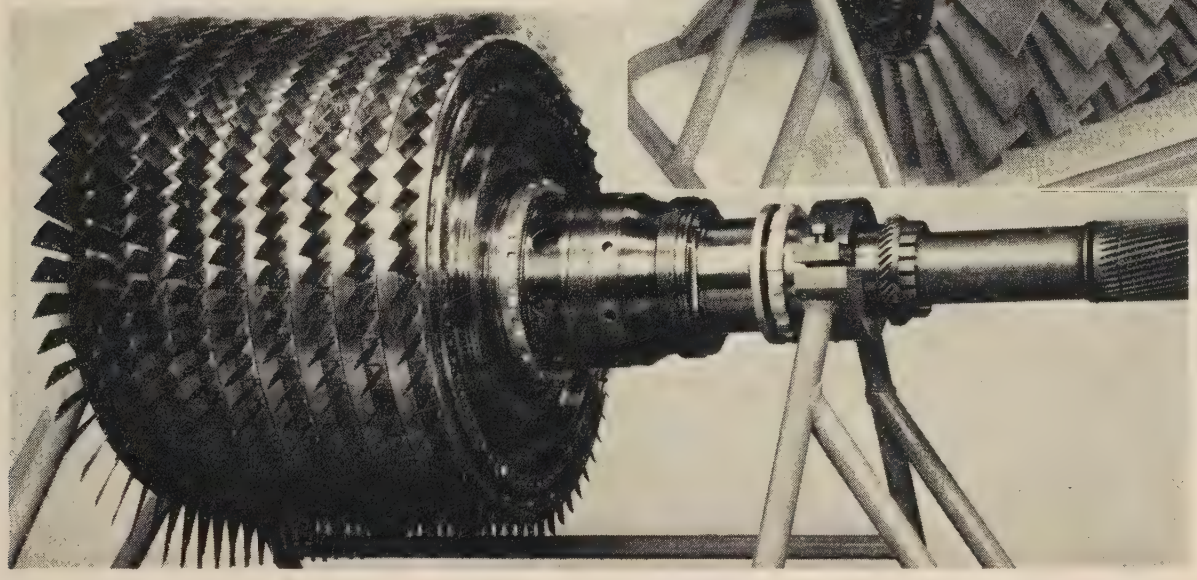
**FLAME TUBE** of Nimonic sheet shows compactness of the engine. Nearly 2000 gas hp is released in each tube. Cooling features of the tubes draw on experience with the Dart tubes, which have achieved up to 3000 hours of operation without repair.



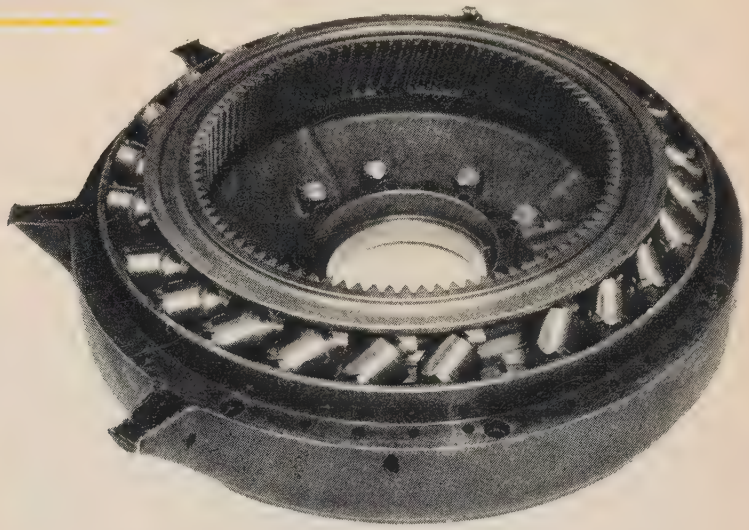

**FUEL BURNER** is a duplex design to insure good atomization of fuel under all flow conditions. The fuel system consists of a fuel backing pump connected to the aircraft system, a fuel heater, a flow meter (if required), a filter, a fuel pump, a flow control unit, a ring manifold, and 10 burner nozzles.

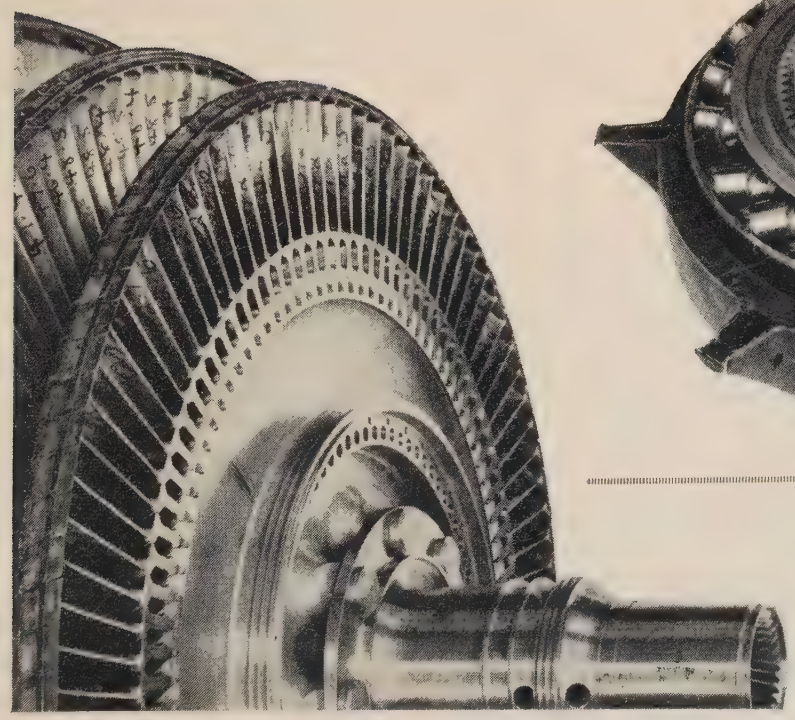
**LOW PRESSURE COMPRESSOR** (right) consists of stainless steel disks and aluminum alloy blades. Pin-fixed blades are used throughout the compressors to lessen resonance and vibration stresses. Below: High pressure compressor has stainless steel disks. Blades are titanium in the first seven stages, stainless in the last two. The disks have "hairpin" roots for automatic centering under all conditions.



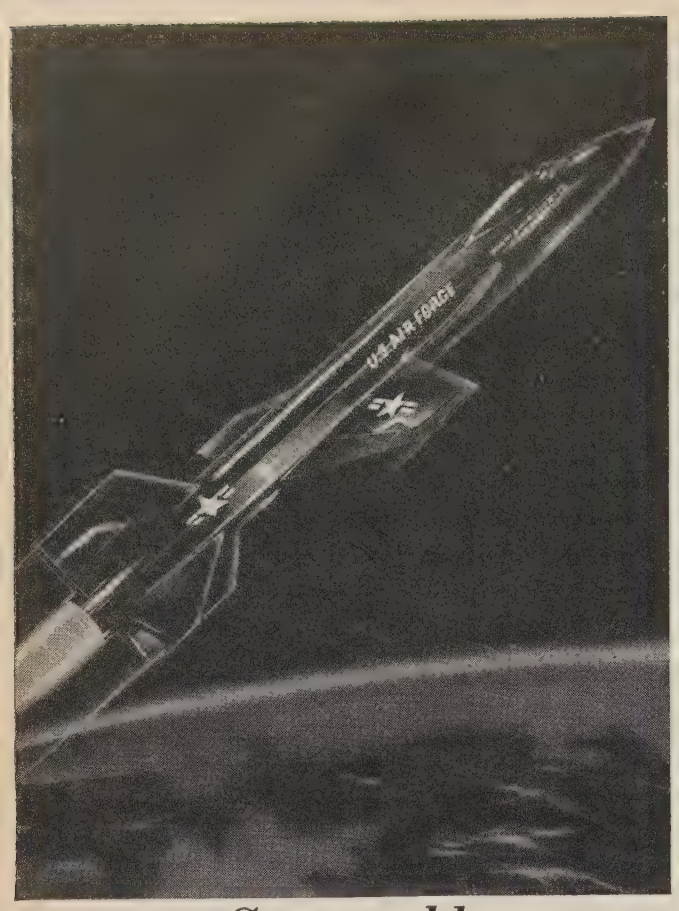


**REDUCTION GEAR** has 0.064:1 ratio, is integral with the engine. Mounting of the reduction gear annulus on 24 tangential hydraulic torque meter pistons provides for torque measurement and allows accurate bedding of gears while reducing vibration. Steel forgings are used in this unit. ▼

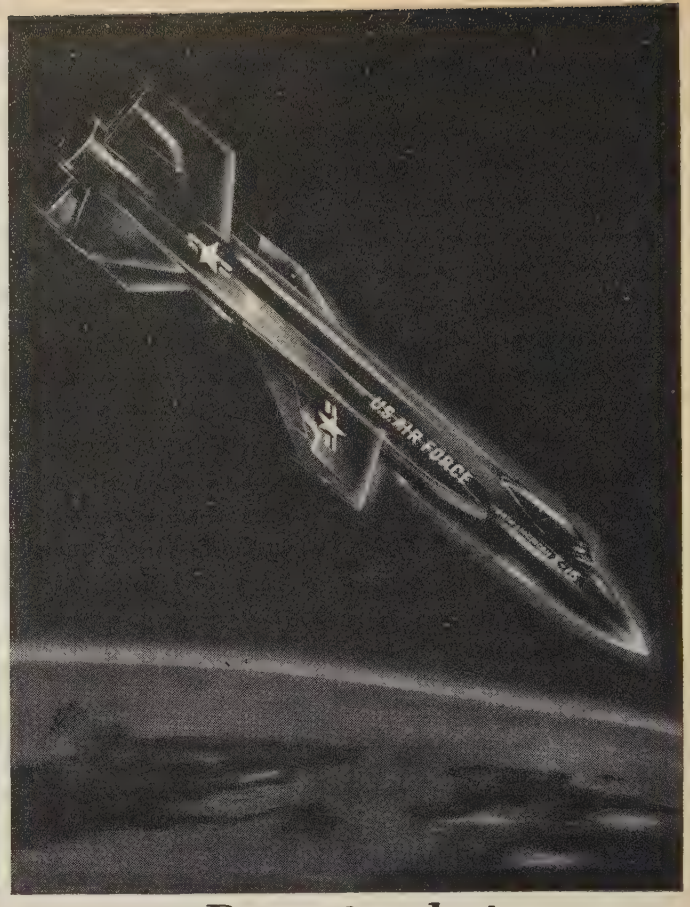




◀ **LOW PRESSURE TURBINE** uses ferritic steel disks and forged Nimonic blades. The extended blade roots of the three-stage design sharply reduce disk rim temperatures. The high pressure turbine (not shown) features air-cooled blading for long-life high temperature operation. Blading details are classified.




*Space cold*




*Re-entry hot*

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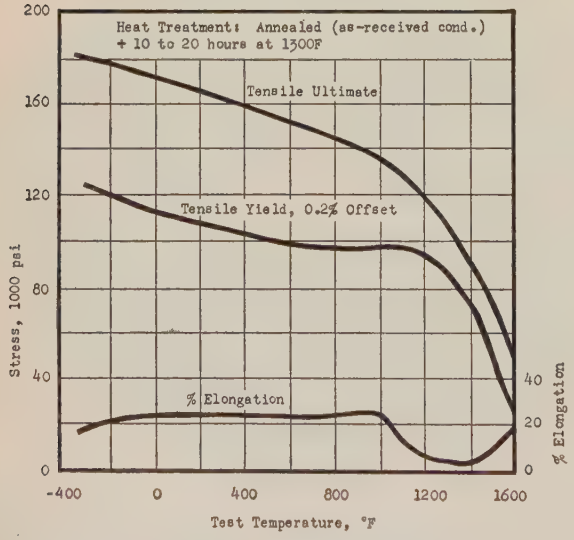


Typical tensile properties of age-hardened Inconel "X" alloy sheet. Note strength at high and low temperatures. Much higher strengths are the additive effects of cold work and age-hardening.

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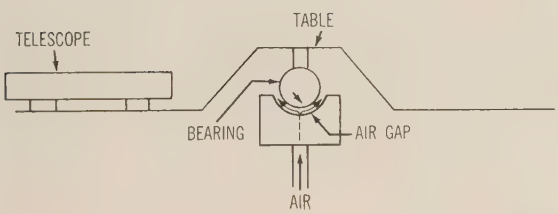
# Astronomical satellite

## must be designed to extreme accuracies

**Successful astronomical satellites represent one of the most important goals of our space program. Here is a report on the major design problems of NASA's "orbiting astronomical observatory" series, slated for launching in 1963-64 to prepare the way for manned astronomical space observatories.**




EXTREME accuracy in all areas of design, from weight and balance to guidance controls, is the watchword for the astronomical-satellite program of the National Space & Aeronautics Administration. Researchers at NASA's Ames Research Laboratory, Moffett Field, Calif., where preliminary hardware design is proceeding, told SPACE/AERONAUTICS that, in one case, pointing accuracy of $\frac{1}{10}$ sec of arc is needed. Close control of mass distribution is also required, since the smallest disturbing force can affect the operation of the satellite's delicate optical equipment.

The astronomical-satellite program covers a series of satellites, the first of which will be an orbiting solar observatory slated for launch in 1960 or early 1961. Ames is also working on an astronomical observatory slated for launch in 1963 or 1964.

The two reasons for astonomical satellites are that turbulence in the atmosphere reduces image sharpness in ground-based astronomical observation and that al-

*more on next page*

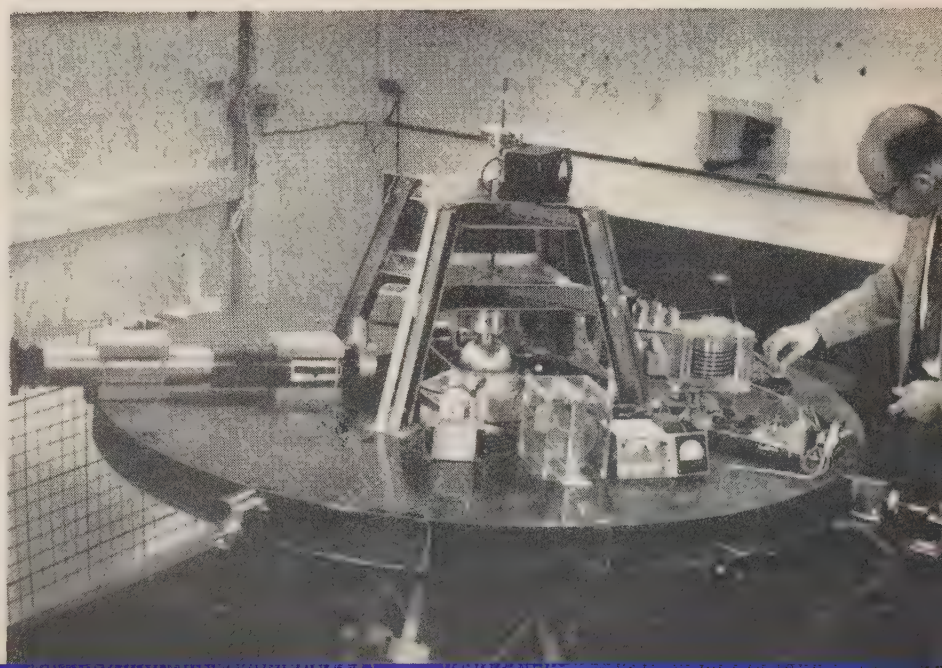


**FIGURE 1:** Torque-free simulator devised by NASA Ames for studying astronomical satellite systems. As the sketch shows, the table is balanced on a metal sphere supported by a compressed-air cushion. In this way, friction is reduced so much that a peanut placed on one side of the table will cause the table to move. The setup includes a star-tracking telescope and inertia wheels for stabilization. Systems can be built on the table to an accuracy of one second of arc.

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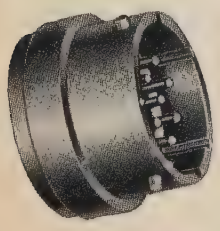

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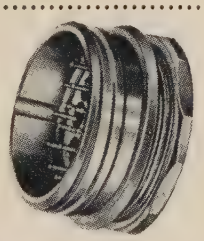

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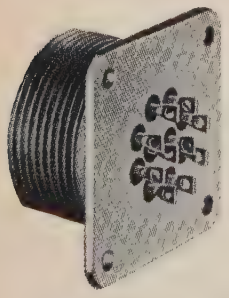

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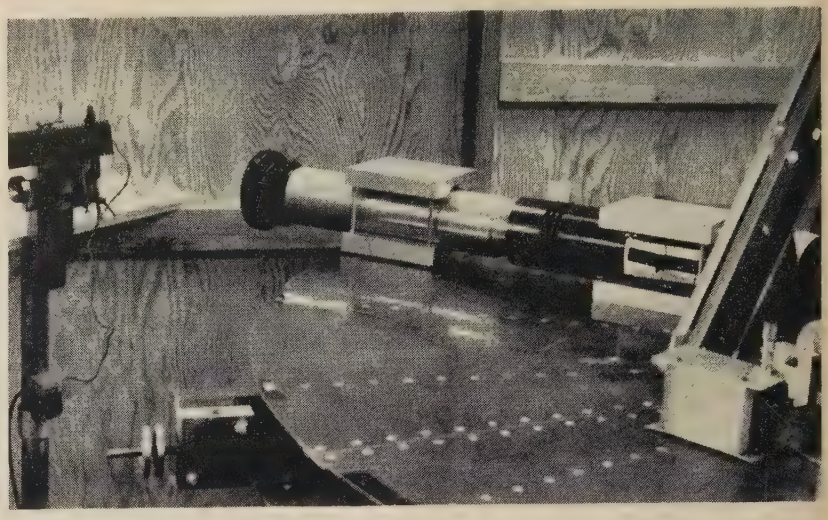


**TRACKING** telescope is trained on a light source simulating a star. Signals from error sensors in the telescope mechanism drive the stabilizing equipment under test.

most all ultraviolet radiation from space is filtered by the atmosphere. A working group of astronomers has programed the satellites for a series of tests using telescopes with a diameter from 8-10 in. up to 36 in. These tests will study the electromagnetic spectrum from 3000 down to 1000 A; in a few cases, they will go as low as 100 A (almost to the X-ray region).

The key problem of the whole program is controlling the satellite in orbit. You can't move the satellite's optical systems—they are too delicate and get out of focus very easily. The only alternative is to turn the satellite.

Reaction wheels provide a possible control method: A flywheel is moved in one direction, causing the whole body of the satellite to move in the opposite direction. If the satellite-wheel inertia ratio is $10^6$, say, then satellite goes through one-millionth of a revolution if the wheel is turned one revolution. The flywheel scheme looks best at present, but other methods (for example, an off-center jet system) are also being studied.

The design problem is complicated by (1) the fact that only a small force is required to rotate the satellite in space and (2) the possible presence of a number of disturbing forces. For instance, the gravity forces acting on, say, the top and bottom of the satellite could be slightly different, producing a torque tending to rotate the satellite away from its proper orientation. The problem can be solved by designing the vehicle so that the mass distribution is as symmetrical as possible, with the CG coinciding with the center of mass.

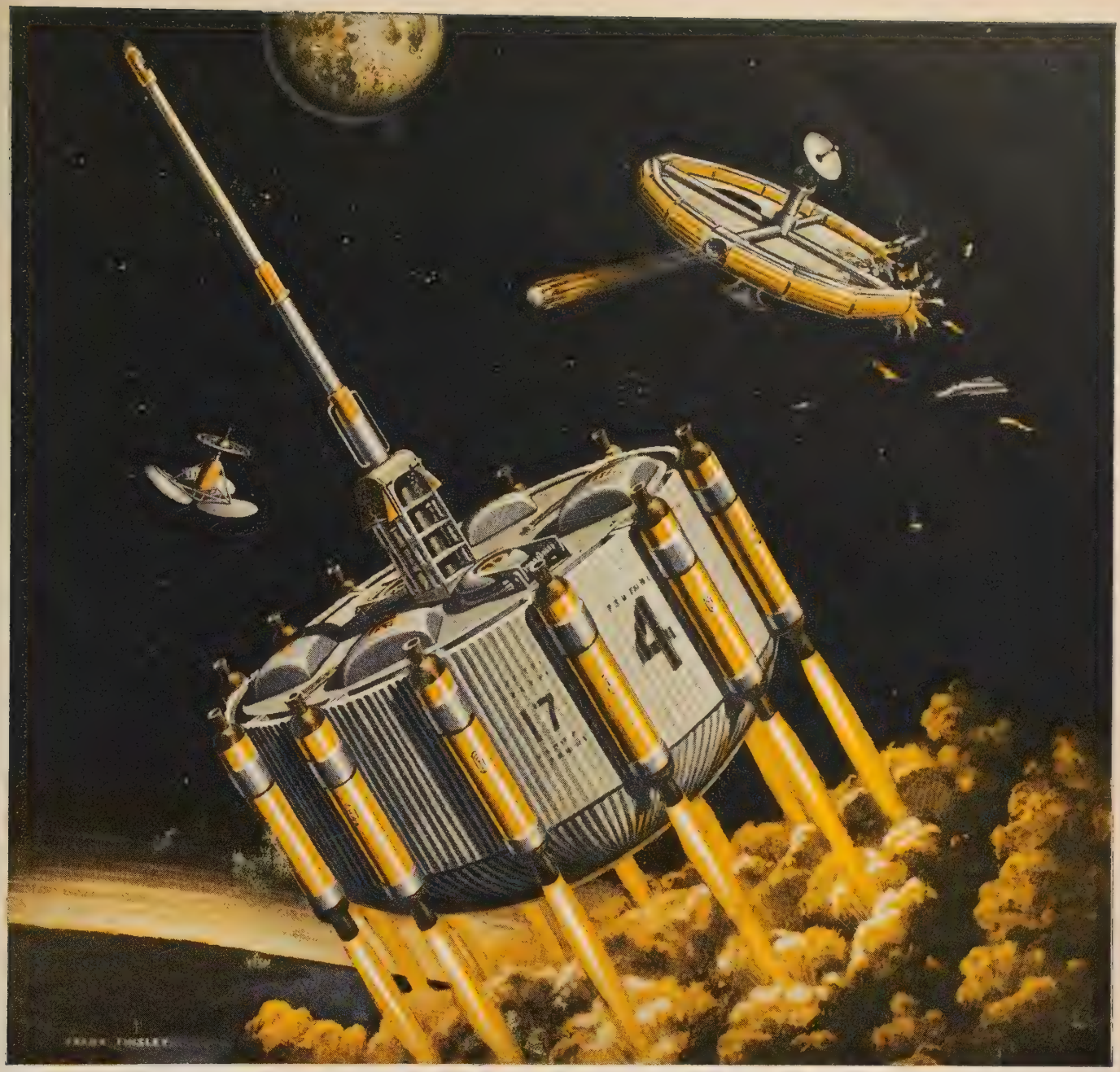
## Center of mass and CP should coincide

The radiation pressure of the sun tends to rotate the satellite in the direction of the sun. To overcome this effect, the centers of mass and pressure must coincide. Furthermore, atmospheric drag pressure must be imposed at the CP to prevent rotation. Material selection is also critical: a vehicle with iron or magnetic coils would want to align itself with the earth's magnetic field.

About a year's life is needed for the satellite equipment, since the telescopes can look in only one direction and therefore take about six months to cover the sky. If gyros should prove necessary for stabilization, NASA points out, this requirement could be met only by pushing the state of the art so far as gyro life is concerned. Also, any rotating mass, as in a gyro, poses the threat of an unbalancing moment. NASA therefore is looking at systems requiring a minimum of moving parts.

Another factor to be considered is the aberration of stars. The 1963-64 satellite will move around the earth at 18,000 mph. The speed of light, of course, is roughly 186,000 mps. Because of aberration, any star therefore has an apparent

*more on page 128*



STEPS IN THE RACE TO OUTER SPACE

# *Escape In Space*

The space-assembled super satellites of the future will periodically encounter disaster—collision, mechanical failure, military attack, or the long chance of being hit by a meteorite. When this happens, "life boats" like the one shown here will bring their crews safely back to earth.

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**1.** Crew members don pressure suits and strap themselves into decelleration beds within the pressure-intact unit.

**2.** At the "Abandon Ship" signal, low-power, RATO-type launching rockets blast the sealed capsule from the threatened station (upper right illustration).

**3.** Acting on orders from an astrogational computer, the retro-rockets check the capsule's speed and break it out of orbit. (Foreground. Note details of offset heat shielding, hatches, slow-down parachute covers.)

**4.** As the capsule enters the outer atmosphere, the heat shield protects the astronauts. The life boat's momentum slows even further, and the shield is jettisoned as it cools.

**5.** Four parachutes are released, acting as air brakes. After a computed interval, other chutes are released.

**6.** The capsule lands in a predetermined sea rescue area, and a ring of flotation bags inflate. A radio broadcasts the craft's location, and a bright sunshade serves as a visual and radar target for rescuers.

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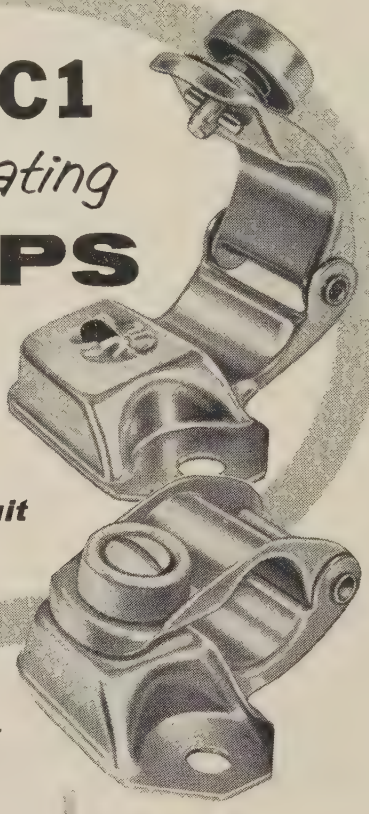

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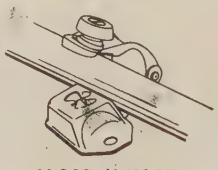

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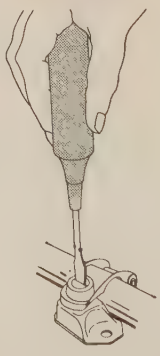

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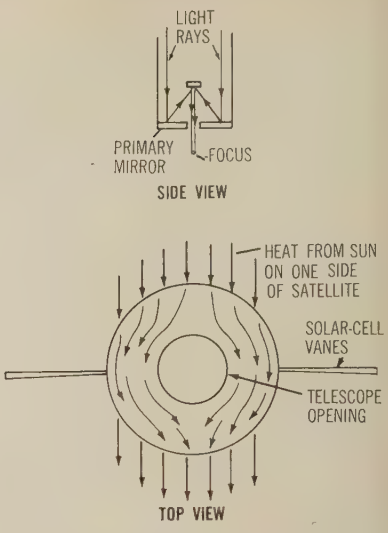


**FIGURE 2:** Rough sketches show possible telescope installation in NASA's astronomical satellite. Careful structural design is needed to direct heat around the telescope opening and dissipate it by radiation. Any temperature differential between the mirrors could throw the telescope out of focus.

movement of several seconds of arc during each satellite rotation around the earth, and the satellite must follow a "moving target" without lagging behind it.

Despite all these problems, NASA researchers believe their astronomical satellite is feasible. Control of one second of arc, they state, seems relatively easy. Getting ⅒ sec poses a tougher problem, but not an insurmountable one.

The 1963-64 satellite, SPACE/AERONAUTICS was told, will be fairly large. Even a folded, Cassegrain-type 36-in. telescope (using solar cells as well as a storage battery for power) is relatively heavy. The overall satellite weight, NASA believes, could well be as much as 1-1½ tons.

Some serious thermal problems must also be considered. *Figure 21* shows a typical mirror setup. Any appreciable difference in thermal gradient between the mirrors would cause them to go out of focus. In some fashion, the sun's heat therefore must be conducted around the vehicle surface without affecting the telescope. Since the satellite is in the dark for part of the time, you also need methods for insulating the optical equipment from intense cold. Some astronomers have suggested the use of quartz for the entire structure.

*more on page 131*

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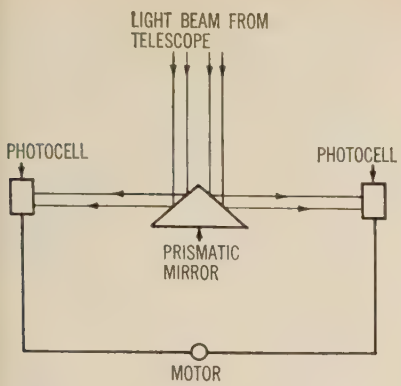


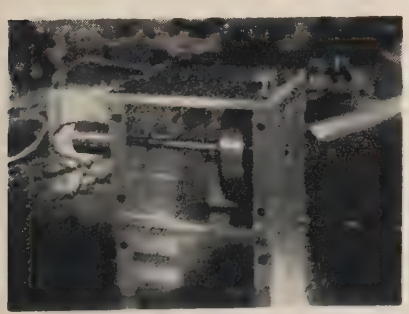

**FIGURE 3:** Possible method for fine telescope focusing splits the beam of light from the telescope with a prism. When the same amount of light is sensed by the photocells on both sides of the mirror, a null is obtained. If there's more light on one side, a signal results and drives the motor.

Because of the need for close weight control, torsion rods and adjustments, ballasting, etc., will be used in the 1963-64 satellite. In addition some equipment will be mounted on rails to permit shifting. Freed from its booster, the satellite is expected to be tumbling. Initial stabilization will stop the tumbling. but then you'll have to find out where the satellite's telescope is pointed.

A TV camera aboard the satellite that has a 10-deg field of view could do this job. From its pictures, an astronomer could tell where the telescope is pointed. He would then use a coarse command control to move the vehicle until he could have the telescope pointing to

*more on next page*

**FIGURE 4:** Closeup of the inertia wheel installation on test table. The wheel, driven by an electric motor, exerts a force at right angles to its axis. By spinning faster, it can exert a larger force. Three such wheels could hold a satellite in any desired stable position, NASA states.



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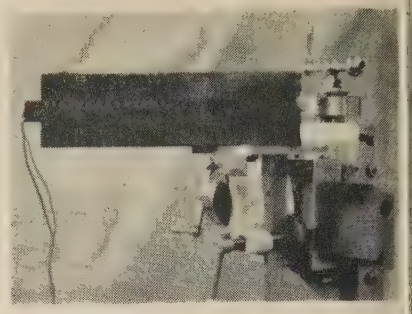


**SIMULATED** star-light source used in current NASA studies.

the vicinity of the star to be studied. Next the fine control would automatically sense the telescope error and focus on the star (*Fig. 3*). Inertia wheels could be used for the control movements—a large wheel for coarse control and a series of small wheels for fine control.

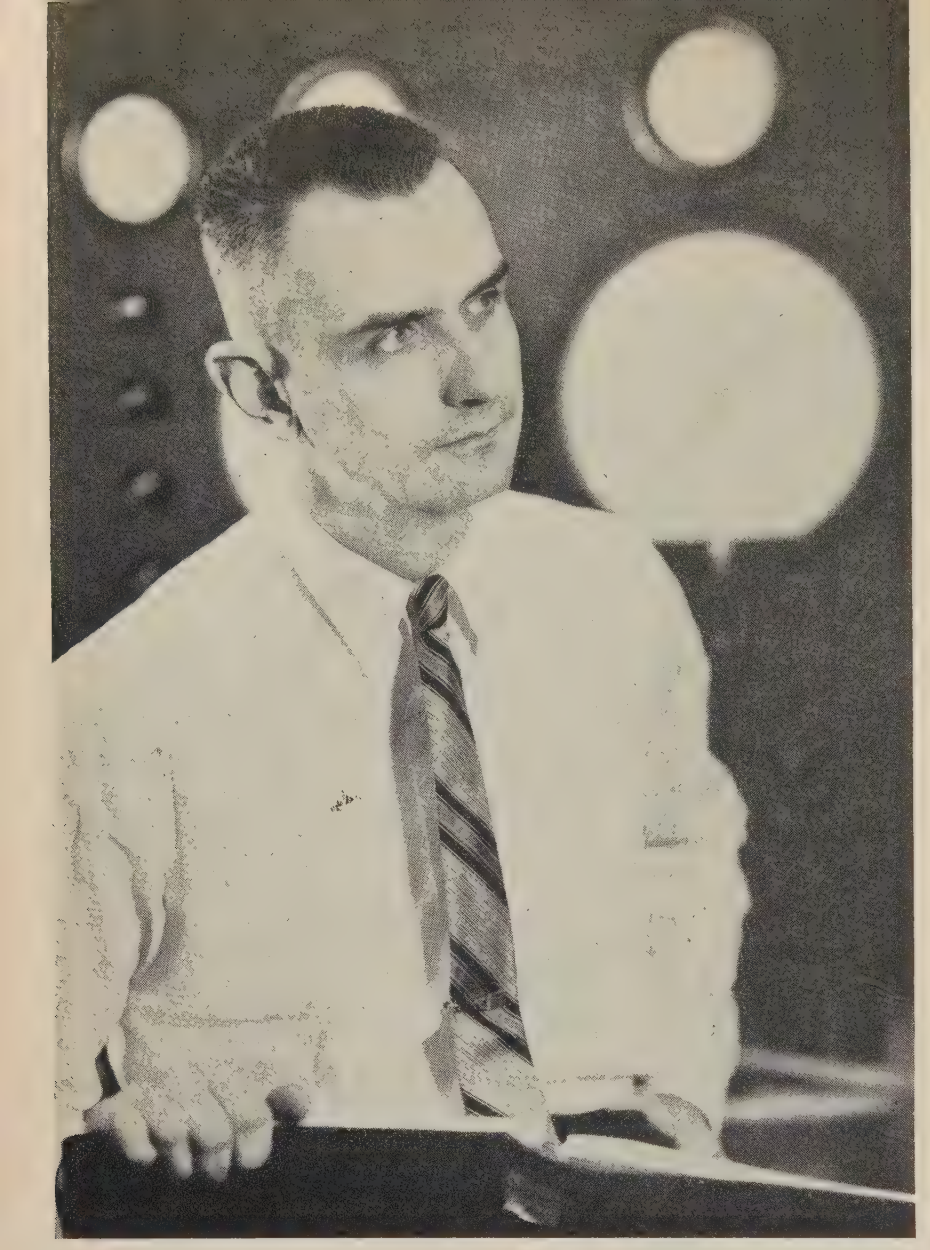
An alternate method would be to have a fixed inertial reference point on the satellite gimbaled to the satellite itself. It would measure the angle between frame and telescope and program a command to move the satellite a fixed distance from the reference frame.

Both approach methods have their drawbacks. The TV method, for instance, makes reliability a problem—the odds are that the TV tube would fail before a year was out. Therefore two separate, redundant systems might be included.

All data from the program, NASA points out, will be spectroscopic. Since no photographs will be taken, the satellite might be able to store data and then transmit them on command over ground stations or relay them to the ground via TV.

In present studies at Ames, an analog computer and a six-foot platform mounted on an air bearing (*Fig. 1*) is used for simulation. The table can be rotated and tipped with forces (as small as 100 dyne-cm). Researchers can analyze their system on the computer and then build it up on the table to an accuracy of one second of arc. Their goal is to design the actual satellite system for disturbing forces in the range of 100 dyne-cm, which would permit an accuracy of $\frac{1}{10}$ sec.

A small motor is used to drive the inertia wheel (*Fig. 4*). The tracking telescope is trained on a pinpoint of light simulating a star. An error signal is picked off sensors on the scope to see how well the system tracks.—**IS**

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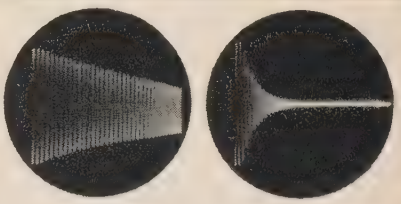

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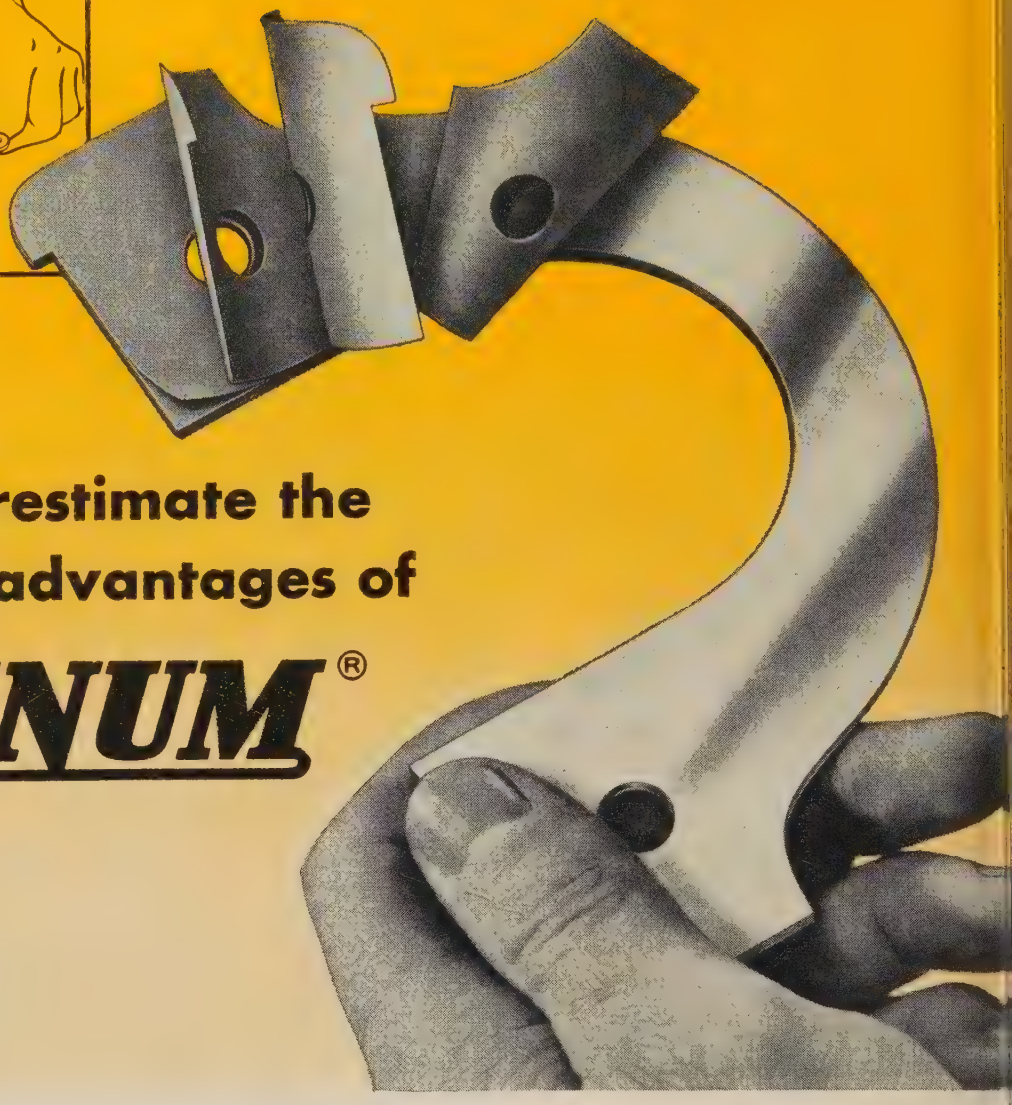

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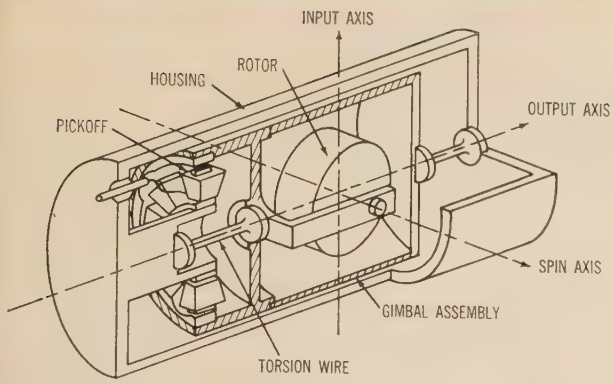


**FIGURE 1:** Fairchild rate gyro with double-torsion-wire suspension.

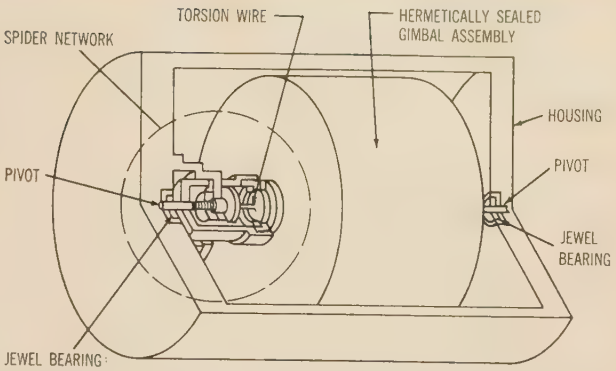


**FIGURE 2:** Rate gyro with double-pivot, single torsion wire, and "self-test" provisions.

# Full-size performance from subminiature rate gyros

**Low dynamic ranges and high accuracy requirements make the design of rate- and acceleration-sensing devices hard enough even in the best of cases. But what happens when, on top of the usual problems, the sensing device must be subminiaturized?**

**by Mike Levitt, Manager,** Gyro Dept., Components Div., Fairchild Controls Corp.*

CAN a subminiature rate gyro be made highly accurate and rugged? It can, but you'll have a tougher time with it than with larger gyros.

Because of limited gimbal volume and fluid density, only 10-20 per cent flotation can be attained in subminiature units, as against better than 99 per cent for the standard sizes. Even this small percentage, however, considerably improves the resistance of the gyro to shock, acceleration and vibration.

In an early Fairchild Controls subminiature gyro, a very fine torsion bar (really a wire) was used to support the hermetically sealed gyro assembly at each end as well as to restrain angular rotation (*Fig. 1*). This system proved highly sensitive to lateral acceleration, which could cause failure of the torsion wires and in any case induced signal errors. It was generally improved when one of the torsion bars was replaced by a pivot working in a jewel bearing.

*Figure 2* shows a design that carried the improvement still further. The gyro gimbal is supported at both ends by pivots and jewel bearings, so that the torsion wire no longer has to support the gimbal. The torsion wire end of the gimbal is suspended from a spider network.

This arrangement enables very low range gyros (e.g., five deg/-sec) to withstand shocks of over 150 g. In fact, only the pivot and jewel design and the gimbal and rotor mountings limit the lateral

more on next page

*Components Div., Fairchild Controls Corp., 225 Park Avenue., Hicksville, N. Y.

g that the gyro can take. The signal error due to lateral acceleration also is sharply reduced—to that caused by clearance between pivot and bearing at the pickoff end of the gyro, which can be kept to a few ten-millionths of an inch. The double-pivot design brings the partially floated subminiature rate gyro close to the fully floated gyro in performance.

Rate gyros formerly were difficult to check out after mounting in a vehicle since there are no angular rates before takeoff. Somehow, therefore, physical motion had to be imparted to the vehicle while it stood still on the ground. With small missiles this was a relatively simple job, but large missiles and aircraft weren't so easy to move around. One solution, used on a supersonic bomber, was to have someone jump up and down on the wing. On one very large missile, someone had to hit the gyro mounting bulkhead. Obviously such methods don't make for smooth automatic countdown.

The subminiature rate gyro of *Figure 2* gets around the checkout problem by having built-in "self-test" features. With a properly designed microsyn-type inductive pickoff, you can check the gyro for several important characteristics without any physical contact: gimbal freedom of movement over the gyro's entire range, friction or threshold level, sensitivity (and therefore the integrity of the torsion wire), and even the damping ratio.

The pickoff simultaneously torques and reads out the gimbal position. You must also know whether the rotor is turning and has attained full speed. The rotor is driven by a synchronous hysteresis motor. A pickoff coil wound around the OD of the gyro housing picks up two signals:

- The rotating magnetic field in the stator provides a signal whose frequency is determined by the number of poles in the stator and the line frequency.
- The magnetic poles formed in the hysteresis ring produce a signal whose frequency is a function of rotor speed.

When the second signal reaches the theoretical synchronous-rotation frequency, the rotor is locked in. A notch filter (designed for the proper speed) eliminates unwanted signals.

In a two-pole, 400-cps motor, the two signals have the same frequency at synchronous speed, so that it's very hard to tell when the rotor has locked in. In this case a notch filter set at 350 cps will show that the rotor has gone through that speed on its way to synchronism. Conceivably this indication won't help you, since the rotor could go through 350 cps and yet not reach 400 cps. The motor characteristics, however, make this possibility very unlikely.

Our rate gyro led us directly to the design of a pendulous accelerometer. This unit measures linear accelerations by means of a spring-restrained, unbalanced mass that uses the same suspension and flotation of a hermetically sealed assembly and the same torsion wire restraint as the rate gyro. The same pickoff is also used to provide self-test capabilities. Circle No. 58 on Reader Service Card for more information.—End

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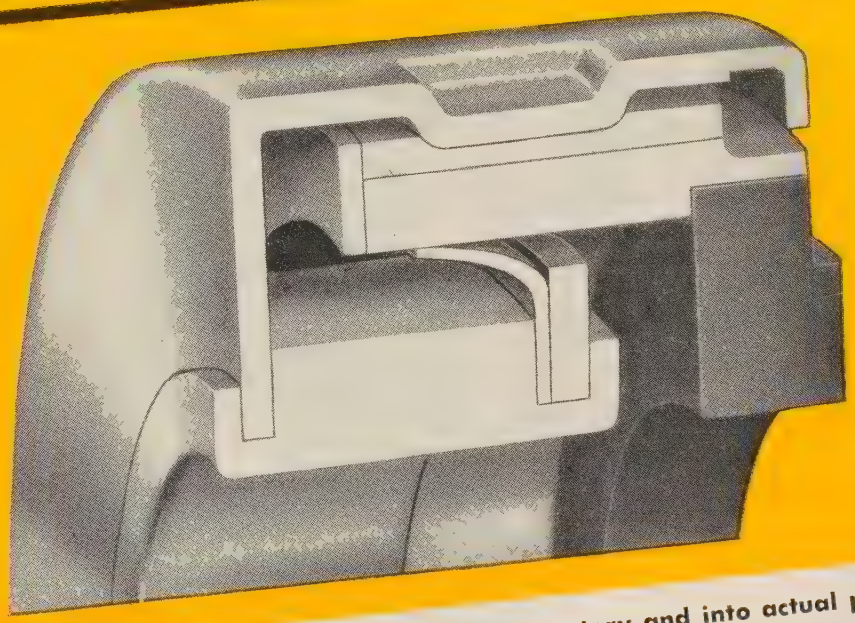

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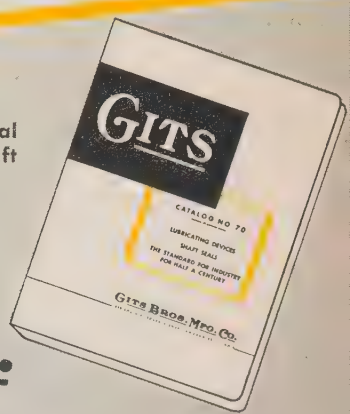


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# Cold-drawing ups nickel's high temperature creep strength

**Creep, has become a major factor in high temperature structural design. As one part of an exhaustive study of this parameter, NBS researchers have found that cold-drawing significantly improves nickel's creep strength up to 900 deg F.**

HIGH temperature creep, flow, and fracture of metals are under study in a comprehensive program at the National Bureau of Standards, Washington 25, D. C. In one phase of this program, which was designed to provide precise data on the effects of cold-drawing on the creep of nickel, W. D. Jenkins and C. R. Johnson of NBS's Thermal Metallurgy Lab worked with high purity nickel specimens cold-drawn to 40 per cent reduction in area.

This test series, NBS reports, shows that cold-drawing significantly increases the creep resistance at temperatures of up to 900 deg F. Above the recrystallization temperature, however, this strengthening effect disappears.

As Jenkins and Johnson point out, creep usually takes place in three stages:

- In the first stage, the rate of extension decreases.
- In the second stage, creep proceeds at a nearly constant rate.
- In the third stage, the creep rate increases until complete fracture results.

It is generally accepted, NBS further states, that the rate of creep is determined by the motion of dislocations through the crystal lattice of a metal.

*more on next page*

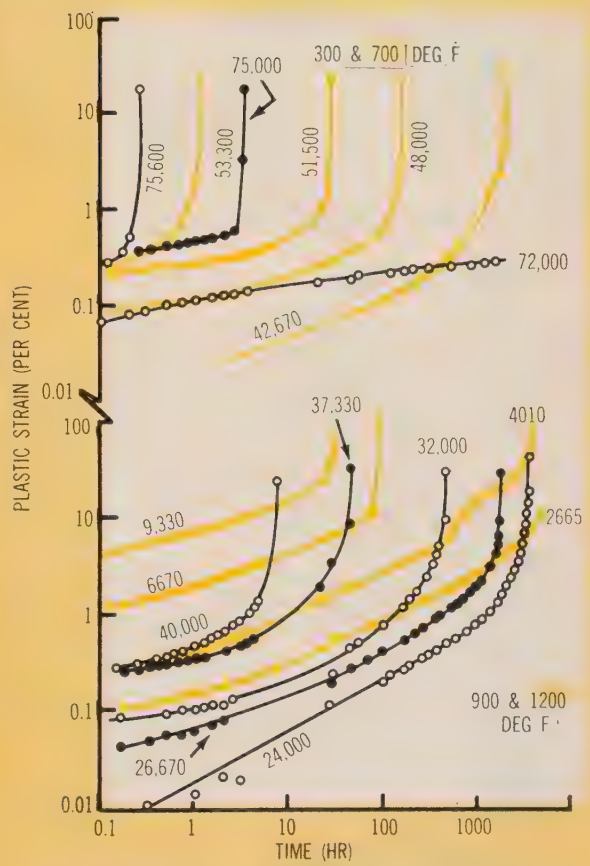


**FIGURE 1:** Strain-time curves for cold-drawn nickel at various creep stresses. (See Table for test durations.)

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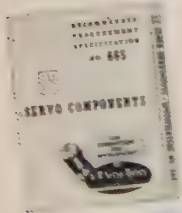

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### Creep of Cold-Drawn Nickel

| Test Temperature (deg F) | Creep Stress (psi) | Plastic Strain (per cent) | | End of Test[1] | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 Hour after Application of Load | Intercept at Zero Time | Time (hr) | Elongation (per cent) | Area Reduction (per cent) | True Strain at Fracture [$\log_e (A_o/A)$] | True Stress at Fracture (psi) |
| 300 | 72,000 | 0.15 | 0.46 | 2297 | 0.46[2] | 0.4[3] | [4] | [4] |
| 300 | 75,000 | 0.47 | 0.37 | 3.2 | 18.5 | 76.4 | 1.442 | 317,000 |
| 300 | 75,600 | | 0.13 | 0.25 | 18 | 78.1 | 1.518 | 345,000 |
| 700 | 42,670 | 0 | 0.07 | 2091 | 26.8 | 82.1 | 1.722 | 238,000 |
| 700 | 48,000 | 0.11 | 0.17 | 164.3 | 23.0 | 83.4 | 1.793 | 288,000 |
| 700 | 51,500 | 0.26 | 0.23 | 27.8 | 22 | 87.8 | 2.064 | 300,000 |
| 700 | 53,330 | 2.01 | 0.15 | 1.2 | 23.5 | 83.6 | 1.808 | 325,000 |
| 900 | 24,000 | 0.01 | 0.19 | 3546 | 42 | 84.5 | 1.863 | 154,000 |
| 900 | 26,670 | 0.06 | 0.31 | 1746 | 30.0 | 82.2 | 1.720 | 149,000 |
| 900 | 32,000 | 0.11 | 0.17 | 452 | 30.3 | 85.0 | 1.901 | 213,000 |
| 900 | 37,330 | 0.35 | 0.30 | 44.5 | 33.5 | 89.5 | 2.219 | 343,000 |
| 900 | 40,000 | 0.51 | 0.29 | 7.5 | 24.5 | 82.8 | 1.761 | 232,000 |
| 1200 | 2665 | 0.15 | 1.2 | 4853 | 8.5[5] | 7.5[5] | [4] | [4] |
| 1200 | 4010 | 0.40 | 1.75 | 3825 | 74.5 | 78.8 | 1.554 | 19,000 |
| 1200 | 6670 | 1.88 | 4.15 | 86 | 97.3 | 97.6 | 3.745 | 281,000 |
| 1200 | 9330 | 6.72 | 7.6 | 28.3 | 62.5 | 97.8 | 3.839 | 433,000 |

(1) Tested to complete fracture unless otherwise noted. (2) Plastic strain. (3) Area contraction. (4) Test stopped in second stage. (5) Test stopped in third stage.

A basic creep research program had already been underway at NBS for several years when Jenkins and Johnson started their studies. The aim of this program was basic data on the structural changes accompanying creep under constant load and at constant temperatures. As part of the program, a study had been completed on highly pure nickel in the annealed condition. Jenkins' and Johnsons' cold-drawn-nickel tests were planned to provide data for comparison with the earlier results on annealed nickel.

## Two studies used the same nickel ingot

Jenkins' and Johnson's test specimens were prepared from the same ingot of nickel from which the specimens had been made for evaluating the annealed stock. They were machined to 0.505 in. diameter and two inches gage length and heated in air to the desired temperature before loading to the required stress. The temperatures of the creep furnaces were controlled to within ±1 deg F over the specimen length. The probable error in measuring the extension increments was less than 0.00002 in.

## Special etching methods were used

The *Table* summarizes the test conditions. After the tests, special etching methods were used to bring out etch figures, etch pits, boundaries of subgrains, and inter-crystalline and transcrystalline cracks.

The test results, NBS states, show that the sensitivity of nickel's mechanical properties to the rate of straining increased with the test temperatures (*Fig. 1*). At constant temperature, this rate-sensitivity value was lower for cold-drawn than for annealed nickel.

The dependence of fracture time on creep stress also increased with

more on page 143

Check Employment Inquiry Form on Page 205

*San Diego Zoo—An original painting by Jack Davis, Convair/San Diego artist.*

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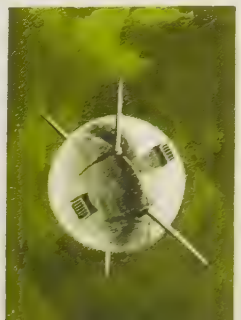

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THE ARTIST — Jack Davis, Convair/San Diego artist whose illustration of San Diego's zoo appears on the preceding page, is a native Californian. He was born and raised in Southern California, and following eight years in the Navy, returned there to study at world-famed Art Center School.

After graduation, he spent a year in Chicago as an artist before returning to California. A family man with two children, Davis has been with Convair/San Diego seven years.

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Electrical Engineering ☐ Aeronautical Engineering ☐ Mechanical Engineering ☐

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**EXPERIENCE:** Primary Specialty _____

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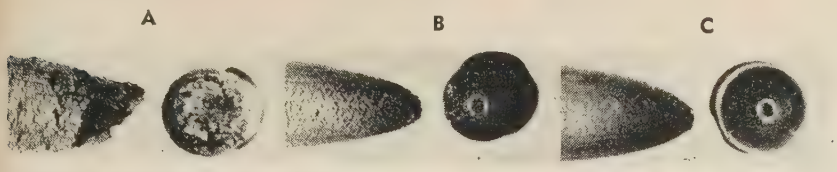
**YEARS OF EXPERIENCE IN PRIMARY SPECIALTY:** _____

Additional Comments, if any, concerning your job interests _____




| | Second-Stage Creep Rate (per cent per 1000 hr) | Elongation in 2 Inches (per cent) | Area Reduction (per cent) |
|---|---|---|---|
| A | 632. | 62.5 | 97.8 |
| B | 72.6 | 97.3 | 97.6 |
| C | 7.9 | 74.5 | 78.8 |

| | Stress (psi) | Creep Rate Rate Second-Stage (per cent per 1000 hr) | Time (hr) |
|---|---|---|---|
| A | 9330 | 632 | 28.3 |
| B | 2665 | 1.24 | 4853 |
| C | 2665 | 1.24 | 4853 |
| D | 6670 | 72.6 | 86 |

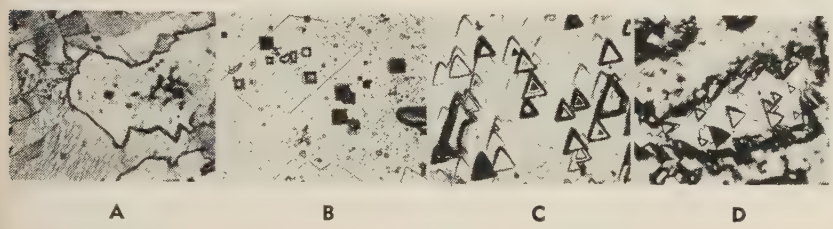



**FIGURE 2:** Cold-drawn nickel specimens (top and left center) fractured at 1200 deg F show the effect of the creep rate on elongation and area reduction. Right center and bottom: Etch figures from NBS cold-drawn creep specimens tested in tension at 1200 deg F and stress data for these specimens. A and B are parallel to the 111 planes, C and D parallel to the 100 planes. The specimens were first etched in a solution of glacial acetic and nitric acid, then in nitric acid and amyl acetate, and finally in nitric and acetic acids.

temperature. However, in the absence of extensive recovery, say Jenkins and Johnson, the logarithm of fracture time varied linearly with the logarithm of creep rate for both the annealed and cold-drawn cases.

An evaluation of temperature-time and temperature-creep-rate relationships showed the stress values for the cold-drawn nickel to be higher than for the annealed nickel at 300, 700, and 900 deg F. At 1200 deg F, the values coincided.

## Elongation was decreased by cold-drawing

The increase in strength from cold-drawing was accompanied by a corresponding decrease in elongation. However, both elongation and area reduction values were less dependent on the creep rate than on the test temperature. The tendency toward localized necking and the formation of transcrystalline cracks decreased with increasing temperature or decreasing creep rate.

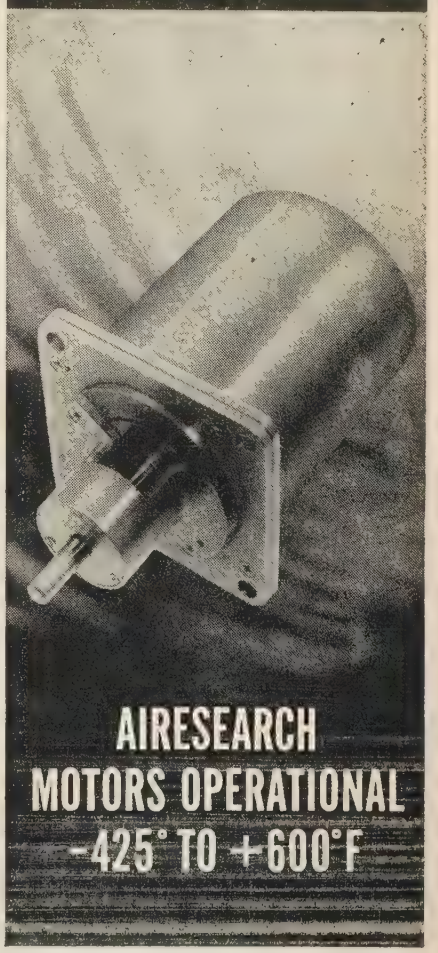
A triple-etch procedure was used on the specimens tested at 1200 deg F. As *Figure 2* shows, it produced triangular figures on a surface parallel to the 111 plane and square figures on a surface parallel to the 100 plane.

## Dislocation sites depend on creep, temperature

These figures, NBS believes, probably represent dislocation sites. Their size appeared to increase with decreasing creep rate or, in the absence of applied stress, with increasing temperature.

The number and density of the etch pits were apparently influenced by both the orientation of the grains and the tendency of the grains to break up into subgrains. All these factors, NBS points out, are known to have a marked influence on the relative motion of dislocations through a crystal lattice.—**IS.**

Electromechanical Components and Systems Capability



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# aerospace electronics

High speed buffer memory drum, key element in semi-automatic air traffic control system being tested by FAA

**JUNE 1960**

## Volscan juggles 24 aircraft with AMP Programming

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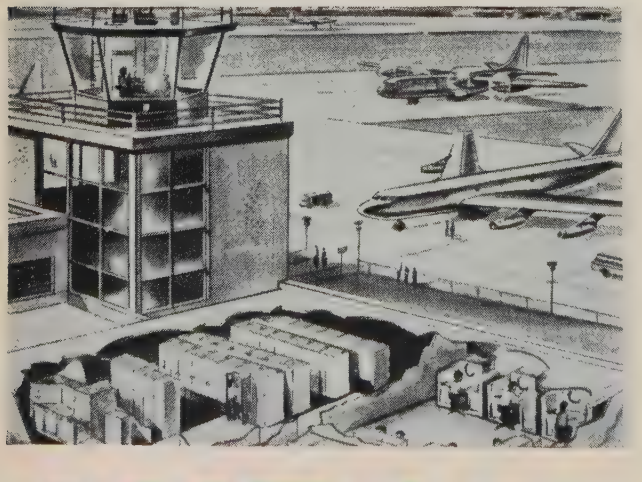

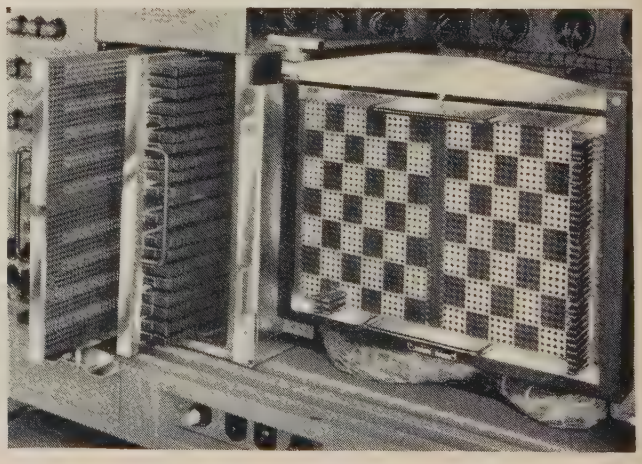

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## Sonar may have rival in sub detection by wake spotting

WAKE DETECTION of submarines is being intensively investigated by a number of ASW research groups both in the Navy and in industry. Studies show the wake of a submerged sub is cylindrical and can be detected far behind the stern. How far behind hasn't been conclusively determined, but the distance is believed to rival that of present operational active sonars.

Some of the mechanisms developed to spot sub wakes sense turbulence, others sense differential heating. It is believed that—at least at the present state of the art—the wake-spotting sensor would have to be physically immersed in the wake.

SOME of the obvious limitations of wake detectors are that they can be fooled by wake producers that aren't subs—decoys, whales, rivers and bays where they enter the ocean, and large thermal discontinuities in the ocean.

•

PROJECT CUTWATER, the Navy's study of the applicability of radar for the detection of submerged subs, is still alive, even though the hopes for success are quite slim. The Navy can't afford however, not to look into all possibilities.

CRYOGENIC GYRO work is going on at Kearfott, Clifton, N.J. GE, JPL, and Arthur D. Little, Inc. are other firms in the throes of "cryo-gyro" research.

## "Brain" proposed as basic inertial sensor for high performance planes

GIMBAL-LESS inertial system for high performance aircraft has been proposed by the two-company team of Chance Vought and Minneapolis-Honeywell in hopes of getting a military contract. "Brain" (*B*asic *r*eference *a*nd *i*nertial *n*avigation) would be the basic inertial sensor for navigation, flight control, flight stabilization, fire control, and data display.

The sensors would be six accelerometers rigidly mounted to the airframe. No gyros would be used. The accelerometers would directly measure both rotations and translations about the airframe axes. Their outputs would be fed to a transistorized digital computer, which would convert them into data giving the relationship of the airframe to the earth. A memory would store this information for attitude referencing and navigation. CV says the effect of the conversion process is the replacement of the conventional mechanical gimbals of the inertial platform with "electronic gimbals."

CV ESTIMATES Brain would require 3.75 cu in., weigh 135 lb, and take about three years from development to production. CV would build the computer system and M-H the sensors.

## Competitive pace is increased as companies angle for government contracts

AEROSPACE ELECTRONICS business is at a low ebb, and many companies in the industry are becoming more and more concerned. In a large number of big and medium-sized firms, over 30 per cent of the engineers are doing non-productive work.

Government people with procuring authority are besieged by a constant parade of sales engineers, project engineers, chief engineers, all seeking contract money to launch new ideas or improve old ones. Competition is terrific, money scarce.

A familiar complaint is that most of the available funds are being spent on a relatively few large projects, so that there aren't enough medium sized and small projects. Another is that, although the defense spending this year will be about the same as it was last year, salaries and fixed overhead costs have gone up, so less can be bought with the money this year.

INDUSTRY IS WAKING UP to the realization that overheads must be cut—but it doesn't know just where to start. One of its worst problems is that many luxuries are now regarded as necessities. It may take a major upheaval to get things back into their true perspective.

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IN SPITE of poor business, the trend for companies to merge or buy up smaller companies is

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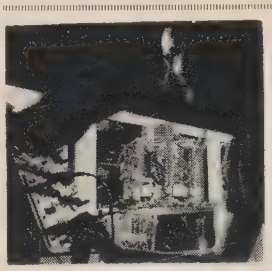

**Cover Story** — High speed buffer memory is part of FAA's semi-automatic ATC system developed by General Precision Labs. Drums spin at 1200 rpm, have eight word blocks with 12-character search key and four-character fixed address.

continuing. Greater capacity (especially for competing for bigger contracts), special skills, and R&D facilities are among the goals of these moves. The going price for established electronics companies is high and is very likely to go higher.

TREND among medium-sized and small electronic companies doing government work is to develop their R&D capability and devote more of their budgets to R&D—for fairly obvious reasons. One is that in the quickly changing field of electronics it doesn't take long for accepted ideas and methods to become obsolete. Government procurement officials realize this and are allocating more funds for basic and applied research. Larger companies have the advantage when it comes to R&D—they can put up more money, hire more top brains, build better facilities, buy better equipment, and also go for longer periods without any monetary return on their R&D.

## *NAECON panelists say universal automatic checkout for missiles is a myth*

UNIVERSAL AUTOMATIC checkout equipment for missiles is a myth, according to panelists at the National Aeronautical Electronic Conference's Ground Support Equipment session. Only about half the checks made on present missiles can be standardized, claimed the conferees. The "non-standard" half requires special test sets. Many of these are quite complex, and almost all are expensive. It was reported that 52 per cent of the checks made on the Sergeant can be applied to most other missile systems. The remaining 48 per cent apply only to Sergeant.

An RCA representative at NAECON reported his company has developed equipment in which the ratio of standard to non-standard checks is 7:3. He was believed to be referring to RCA's DEE (*D*igital *E*lectronic *E*valuation) system, originally designed to check out Corporal, Hawk, Lacrosse, Nike-Ajax and Nike Hercules. Most of the conferees considered RCA's claim inflated and a 50-50 ratio to be nearer to the truth.

DUPLICATION in checkout equipment was one of the problems discussed at the NAECON GSE session. Most of the participants agreed that merely finding out whether a specific test set exists and is available through government channels takes at least three months. So a contractor who can't afford to wait that long usually goes ahead and designs his own test set. Some time later he may then discover that a set essentially similar to his had been in existence all along.

Some members of the audience doubted that a catalog search to avoid duplication takes three months. One engineer claimed that by teletype query to the Air Materiel Command, you can find out within a week whether a certain type of test equipment exists or not.

NINETY PER CENT of the cost of future weapon systems will go for GSE, predicted Claude T. Everson, GSE supervisor at Lockheed's Missiles & Space Div. He also estimated that total GSE spending in fiscal '60 would top $2.5 billion and that some 65 per cent of this figure would go for electronics.

What Everson meant by GSE wasn't clear, GSE being a hazy term. To some it means only checkout, handling, and launch equipment, to others, all the construction associated with a launching site. There is a trend on in some parts of the industry to call all the ground electronics for a weapon or satellite system "ground support electronics." This definition would include, for example, the ground radars and computer for a radio command guidance system.

## *Not-so-rosy future predicted for molecular electronics in NAECON talks*

DOUBTS ABOUT molecular electronics were expressed in NAECON papers by Dan Noble, executive vice president at Motorola, and Julian Sprague, president of Sprague Electric. Both said that conventional components, printed circuits, transistors, etc., would be used for many years to come and predicted that what molecular designs will be developed will be hybrids—only part of the equipment will be made in monolithic blocks.

Noble pointed out that "so far we haven't even solved the surface-phenomena problems for transistors, and the surface problems relate to the fundamental problem of terminating impedances". It took us 10 years to develop transistors to the point at which they are today, he stressed. So it's reasonable to assume that 10 years may also be needed for comparable progress in developing the functionally much more complicated monolithic structures, even though we have a head start in the semiconductor art, Noble concluded.

WHO WILL MAKE the integrated electronic structures—the manufacturer or the system and

more on page 150

ACTUAL SIZE

This is the actual size of Heinemann's new sub-miniature circuit breaker, the SM3. Hermetic seal and all, it weighs no more than a bantam 2.1 ounces. It is magnetically actuated, therefore does not require de-rating for high ambient temperatures. In fact, under extensive environment-testing, the breaker has demonstrated excellent all-around operational stability. It will function properly on the tundra or in the tropics, will withstand the onslaughts of salt-sea atmosphere, sand, dust and high humidity. The SM3 is available to your specifications in any integral or fractional current rating from 0.050 to 10 amperes, at 110V, either 60 or 400 cycles AC, or 50V DC. And you have a choice of either fast or slow time delay, so that overload response can be matched closely to the operating characteristics of the protected equipment. If you have need of a rugged, compact circuit breaker "packaged" to go anywhere, you'd do well to give the SM3 some serious consideration. The facts and figures are presented for your review in Bulletin 3502. Write for a copy today.

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subsystem manufacturers? Both, said Noble. He believes that, if functional blocks are bought "ready-made," the system designer will lose control of the system design and actually become superfluous. The system manufacturer, he warned, couldn't afford to yield the essential control of the system's parameters to the suppliers of monolithic blocks.

Speaking about the electronic engineers of the future, Noble said that it would be more difficult to train the solid-state-electronics physicists to become good engineers than it would be to train today's engineers in solid-state electronics.

## No appreciable effect foreseen for molecular electronics until well after '65

DENDRITIC GROWTH was questioned by Sprague: "It is claimed that, at least in the laboratory, a PN-junction effect can be grown in a dendritic crystal, but I have seen no data which indicates the uniformity of the process." He also questioned adequacy of the yield in making molecular circuit blocks. The yield, he said, "more than any other . . . factor, will determine the cost and therefore the breadth of these functional blocks."

Sprague warned against "prophets who would have you believe that, once they are ready for production, these new devices will supersede all that we have now." He predicted that, by '65, probably the only significant use of molecular electronic designs will be in satellites, where their applications will be justified only by the high cost per pound of payload. Otherwise, molecular electronics will have no appreciable effect until well after '65, he claimed.

•

DEFENSE ELECTRONICS accounts for about half of the electronics industry's total output in the U.S., estimates Jim Bridges, director of electronics in the Office of the Director of Defense Research & Engineering. He also claims that defense supports about 80-90 per cent of all the country's electronic research and engineering resources.

APN-110 RADAR ALTIMETER being produced by RCA for the Convair B-58 Hustler weighs less than 35 lb. It has a range from 500 to over 60,000 ft and an accuracy of ±25 ft plus 0.025 per cent at any altitude in this range. It is used mainly for weather mapping, photo recon, and pressure-area navigation.

"ADVANCED Guidance System" (AGS) developed by Space Technology Labs was used on the Thor-Epsilon vehicle that sent Transit I-B into a decidedly elliptical orbit (470-mile perigee, 270-mile apogee). A circular orbit of about 400 miles was planned; the ellipse resulted from malfunctions in the guidance. AGS is believed to be a preprogramed system with radio command backup.

CUTS IN SAGE funds have saddled defense and air traffic control planners with a dilemma. Originally the idea was to try and weave Sage into our air traffic control network—partly to avoid the duplications of radars and control facilities and mostly to justify the monstrous costs of the defense control and warning system. Now apparently there have been second thoughts about Sage at top Pentagon levels—an attack by manned bombers and/or air-breathing missiles is considered much less of a threat than an ICBM attack, and the manned interceptor and the anti-aircraft missile (for which Sage was designed) have become less important as defensive weapons.

Mitre is studying the SAGE-ATC tie-in possibilities in the light of these recent changes in planning.

## Winter report expected to influence the L-systems' fate

THE PATTERN for USAF's electronic systems for the near future, at least, is expected to be set by the report of the USAF-industry Winter study group. The group has 15 panels, covering communications equipment, cost, data processing equipment, use of data processing equipment, design methods, display, human factors, logical concepts, logistics, reliability, sensing equipment, special studies, threat, vulnerability, and weapons.

In addition to many of the large electronic firms, AMC, ARDC, Mitre, Rand, Space Technology Labs, and USAF Headquarters, are represented on the panels.

The Winter report is certain to have an important bearing on the fate of the L-systems now in the works.

•

TIME-DIVISION data link designed by RCA will go into all operational USAF interceptors and Bomarc B missiles—Model ARR-56 into the F-105B, ARR-60 into the F-101 and F-102, ARR-61 into the F-106, ARR-62 into the F-104, ARR-65 into the F-105D, and DRR-1 into the

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## nother Philco achievement global communications

part of a major study of space communications tech-ues, Philco is prime contractor for an Air Force project relay high frequency radio communications around the vature of the earth, through space. Known as the ssive Satellite Relay Link, it will reflect voice and tele-e signals from a 100 ft. aluminum-skinned plastic balloon. der NASA's Project Echo, the balloon is to be launched a 1,000 mile earth orbit for use as a passive commu-ations reflector.

The parametric amplifiers, receiving antennas, and track-and receiving systems are Philco designed, built and alled. The entire program is managed by Philco, under supervision of the Communications Directorate, Rome Development Center.

This is one more step in man's utilization of outer ce . . . and another important Philco achievement in al communications. For capacity, facilities and expe-ce in advanced electronic systems, look to the leader . . . to Philco.

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Bomarc B. All models of the data link are hybrids. Tubes are used in the higher frequency and higher power stages; the remaining stages are transistorized.

Many presently operational F-86, F-102, and F-106 interceptors carry the frequency-division data link built by Electronic Communications. RCA says USAF will soon phase out the frequency-division models and retrofit time-division systems.

## "Fact book" makes pitch for receiving tubes

SEVEN LEADING producers of electron receiving tubes have taken up the cudgels for their "undersold" products in a half-inch-thick "fact book" entitled "Tubes and Transistors: A Comparative Study." The book, which argues for more attention to the relative merits of the two devices for particular applications, was put out by The Electron Tube Information Council, 554 Fifth Ave., New York 36, N.Y. Reportedly set up only to produce this book, the Council is made up of top engineers representing the tube departments of CBS Electronics, GE, Raytheon, RCA, Sylvania Electric, Tung-Sol Electric, and Westinghouse. The book's avowed purpose is "to help management and design personnel answer these questions in terms of their product requirements:

- Which device offers the better combination of characteristics for equipment being designed today?
- Which device will most likely be better for equipment of the future?

THE BOOK seeks to dispel any idea that tube technology remained fairly static while transistors were making rapid progress. Tube progress, the book claims, is shown by better high frequency performance, higher power efficiencies and smaller sizes. RCA's nuvistor is cited as an example to show how small, rugged, and temperature resistant—and shock—tubes have become. Materials research is keeping the tube well up with both present and future environmental requirements. Heaterless, self-heating, and cold-cathode tube designs hold great promise for better reliability.

The point to keep in mind, according to the book, is that progress is being made on both sides and there is no universal answer to the question: tubes or transistors? The choice must depend on the application.

■

CONTRACT for the electronic computer used to control Mauler, a highly mobile missile system designed to defend against tactical aircraft and missiles over a battlefield area, was awarded to Burroughs by Convair-Pomona, the system prime. To give the control computer the mobility to match the roving weapon system, Burroughs is designing systems that can be carried by copter or STOL aircraft and can withstand a parachute drop into the battle zone. Each Mauler unit will be self-contained and housed in a single vehicle from which it will have to direct accurate fire even with the vehicle moving over rough terrain.

VIDAC (*V*isual *I*nformation *D*isplay *A*nd *C*ontrol), a solid-state character generator that displays letters, numbers, and symbols with ultra-high speed and resolution, was developed at CBS Labs. Electric impulses are passed at very high speeds through a fine magnetic-wire matrix to produce an output that can be used as a symbol on a CRT.

The CBS engineers who developed Vidiac point out that their device—which takes up less than two cubic feet—uses a word-oriented, wired-program-type memory with non-critical ferrite switch cores to store the character shapes. A highspeed, parallel-to-serial converter is used to get very high video signal frequencies from a relatively low speed cores.

## Vidiac said to be useful for any simultaneous display of hundreds of items

OPERATING ON ONLY 40 W (which eliminates circuitry hot spots), Vidiac should prove useful for many kinds of data processing, control stations, master situation displays, etc.—wherever simultaneous display of hundreds of items of changing intelligence would be needed. Reportedly, four Vidiacs are slated to go into a large military data processing system developed by Thompson Ramo Wooldridge.

■

SEALING by optical polishing was first adapted to tube production by CSF, in France. The Signal Corps picked up the idea in '56 and has had Chatham Electronics evaluate it. The results of Chatham's pilot study show that "polyoptically" sealed tubes far outlive conventional flame-sealed ones. In a 2000-hour life test, about 60 per cent of the experimental polyoptically sealed tubes continued to work even after all the flame-sealed tubes in the control sample had failed.

Signal Corps now is concentrating on developing a refined volume production method for the new sealing technique in a two-year program.

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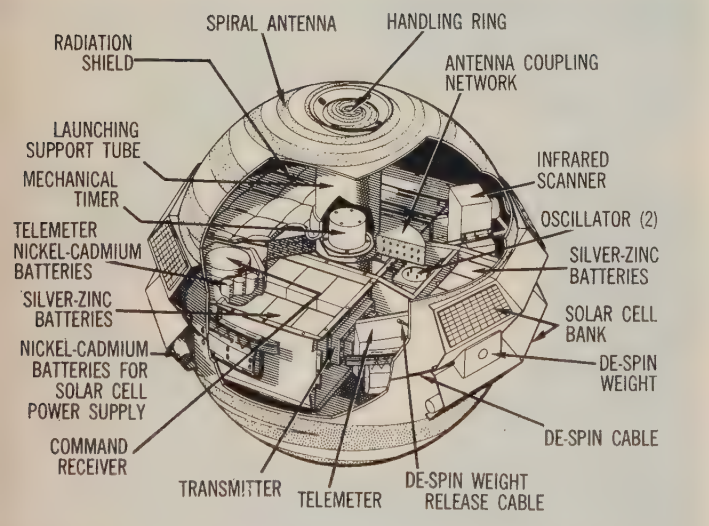
# Transit:

## Navy claims world's first operational satellite




**EQUIPMENT** carried by Transit IB. All the electronics are transistorized. The entire electronics package is mounted on a tray laced by nylon cord to the skin of the satellite. This suspension keeps the thermal conduction from the skin to the tray very low. A blanket about ⅛ in. thick and consisting of layers of aluminum foil and fiberglass filter paper acts as a shield against thermal radiations.

**With the Transit IB in a successful orbit, the Navy is sure it is well on its way to putting up "the world's first operational satellite." Here is a report on how this satellite, which is really an all-weather navigation aid, will work.**

**by James Holahan,** Electronic Editor

PRECISE NAVIGATION today is possible only at the price of complexity. A good case in point is the tremendously complicated ship's inertial navigation system (SINS) designed for Polaris-carrying submarines—there just is no simple way for a sub to locate its position precisely enough for launching ballistic missiles. And even with SINS, precision breaks down when the weather is so bad that no celestial fixes can be taken over a long period.

In the future, the problems of equipment complexity and celestial "blackouts" both may be overcome by the Transit Satellite System, which is being developed for the Bureau of Naval Weapons. Actually Transit—which will provide position fixes accurate within ¼-½ miles, is not meant to replace SINS, says BuWeps. It is a badly needed simple, precise all-weather navigation system for subs, surface ships and possibly aircraft. That it could improve SINS is an incidental benefit, claims the Navy.

The Transit system is being developed by the Applied

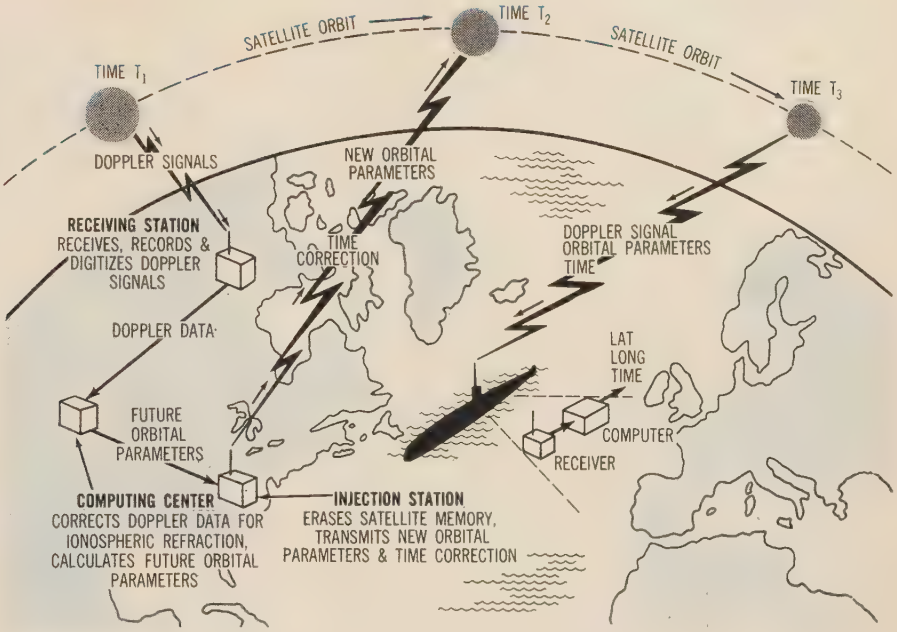
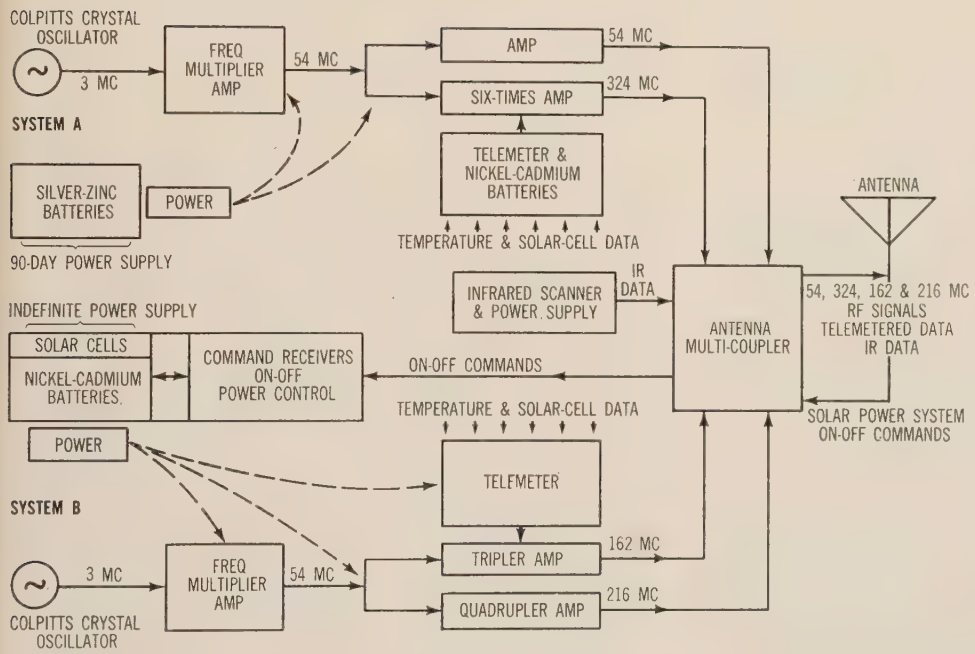



**FIGURE 1:** System operation of the Transit satellite.



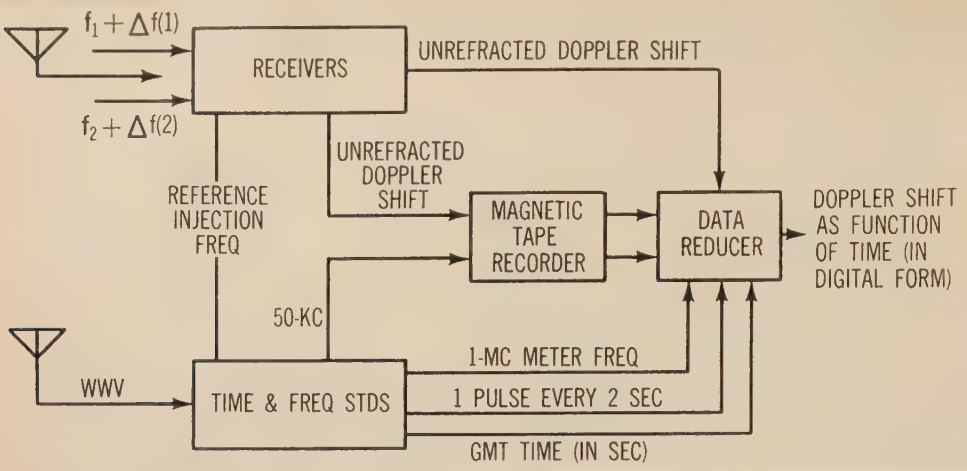

**FOUR** harmonically related signals are broadcast from Transit IB for test purposes. A 108.3-mc signal broadcast from a separate transmitter failed after two days of operation. Short-term stability of the oscillator is better than one part in $10^8$. In the operational system, only two signals will be transmitted.

Physics Laboratory (APL) at Johns Hopkins University, Charles & 34th Street, Baltimore, Md. Essentially it reverses the method used by the Russians, APL, and others for plotting the satellite orbits by measuring the Doppler shift of their radio transmissions. In this situation, the satellite is tracked from a known position on earth. In Transit, the orbit of the satellite is known and the position of the observer on earth—the navigator of a sub, surface ship, etc.—is unknown. His navigation problem is solved by determining his position on the earth relative to the known satellite orbit.

*Figure 1* shows the overall system. A satellite in a nearly circular, 400-500-mile orbit transmits a pair of signals each on a different but harmonically related frequency. Frequency stability must be within one part in $10^8$ during a pass of the satellite (which lasts about 10-15 minutes).

The satellite is tracked by ground stations, its orbit is computed, and updated orbital data are sent up to it twice a day in digital form. The satellite stores the updated information and uses it to modulate its radio trans-

***more on next page***




**RECEIVING** stations derive unrefracted Doppler shift with the aid of time and frequency standards. The output is punched paper tape with digitized signals of the Doppler shift as a function of time.

missions about once every minute. Time corrections are also sent to the satellite from the ground stations and returned to the ground navigator as modulations of the carrier. A binary-coded, phase-reversal modulation is used for both orbital and time data.

The navigator on earth pinpoints his position by determining the Doppler shift of the satellite signals during the pass of the satellite. This shift represents the time rate of change of the electromagnetic path length of the satellite signal and therefore is a measure of the slant range from the navigator to the satellite, assuming the signal path is direct. (According to APL, the data it has analyzed so far show no evidence of multipath. However, APL thinks multipath might prove troublesome in the auroral regions, particularly during magnetic storms.)

## The navigator compares two curves

Having found his own Doppler shift-time curve, the ground navigator compares it with a theoretical curve using orbital and time data received from the satellite. The result is a latitude and longitude fix that is accurate to within ¼-½ miles.

To use the Transit system, the navigator must receive:

- two harmonically related signals (harmonically unrelated would require a more complex receiving system);
- the orbital elements of satellite (in digital form);
- accurate time signals;
- precise information on his own ship's velocity from conventional navigation equipment.

A velocity error causes an error in ship's position during the pass and as a result a navigation error. APL estimates that such a navigation error amounts to about one-half to two-thirds of the total ship's position error.

The navigator uses this information as follows:

- He combines the two received frequencies to eliminate ionospheric refraction, obtaining the "vacuum Doppler," or the Doppler shift that would exist if there were no atmosphere.
- He assumes a position (from other navigational inputs aboard) and, knowing the ephemeris of the satellite, calculates the theoretical Doppler-time curve for this position.
- He plots the actual Doppler-time curve, using the received vacuum Doppler data.
- He matches the actual and theoretical curves. The match tells him which way he must move the theoretical curve to fit the actual one. Own-ship velocity is introduced into the computations to correct for own-ship movements during the pass of the satellite.

To take advantage of Transit a ship must have a pair of receivers with a comparison circuit for canceling ionospheric refraction and a computer. According to Dr. Richard Kershner, supervisor of the Transit project at APL, this equipment can vary in complexity. With a simple receiving system, and a hand calculator, the navigator can get accuracies of half a mile. With a digital computer, he can get better than a ¼-mile accuracy, Kershner says. In fact with such a computer the accuracy limit would be that of the maps of the earth's surface. In other words, we won't be able to take full advantage of Transit until we have better maps (which we won't have until we find out more about the actual shape of the earth).

In manual navigation, the navigator relies on the fact that, roughly speaking, the maximum slope of the Doppler-time curve is inversely equal to the slant range between him and the satellite. The locus of points of equal slant range is a hyperbola. By making many determinations of actual slant range, the navigator can draw a series of "iso-range" hyperbolas whose intersection is his position. If his velocity is more than two knots, he must correct for it to get half-mile accuracies.

The digital computer essentially does the same thing, only it takes many more points and its computations naturally are more precise. With a digital computer, it takes about five minutes to fix position.

According to the APL's Drs. W. H. Guier and G. C. Weiffenbach, there are two reasons for the remarkable accuracy of the Transit system:

- Both frequency and time can be measured quite precisely.
- There is tremendous redundancy in the information contained in the Doppler-time curve. Each pair of points on the curve can locate the navigator's position, and each is more or less statistically independent (assuming that any errors are statistical). The best use of the redundant data is made by applying curve-fitting techniques like the least-squares method, claim Guier and Weiffenbach.

Since it wanted to use transistorized RF stages in the satellite and yet avoid the refraction problems of transmission through the ionosphere, APL decided on transmission frequencies in the 200-400-mc range. The refraction effects at these frequencies are not gross, but they still had to be eliminated if APL was to get the

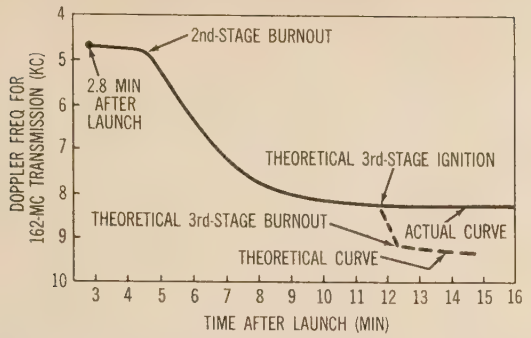



**FIGURE 2:** Predicted and actual Doppler shift curves for Transit. The measured curve for 162 mc is from the short-lived Transit IA flight.

precision it wanted. (Uncorrected refraction of a 200-mc signal would cause a navigation error of about two miles.)

Using two transmitted frequencies, APL's correction scheme takes advantage of the dispersive effects of the ionosphere. It is based on the fact that the Doppler shift in the presence of the ionosphere can be represented mathematically as a power series in $1/f$. APL determined that the first-order term in this series is the only one contributing to errors that affect the desired precision. Multipliers and mixing circuits in the receiver extract the difference between the two received signals and eliminate the first-order term. What is left is a term representing the difference between the square of the frequencies times the time rate of change of the slant range plus higher-order terms that can be disregarded because of their negligible effect. Essentially, the "vacuum" Doppler is:

$$(f_2^2 - f_1^2)\,\dot{\rho}/c,$$

where $f_1$ and $f_2$ are the transmitted frequencies; $c$ is the speed of electromagnetic radiation in a vacuum; and $\dot{\rho}$, the time rate of change of the slant range. The $\dot{\rho}$-term contains all the information in the Doppler shift.

APL claims that, by using two frequencies above 200 mc, it has reduced refraction errors to less than 0.5 miles. Because of the harmonic relations between the two frequencies, conventional circuits can be used in the receiver.

Two Transit satellites have been launched so far. The first failed to go into orbit but yielded valuable data during its short flight (*Fig. 2*). The second, Transit IB, is orbiting in an ellipse with a 470-mile apogee and a 235-mile perigee. Its period is 95.5 minutes and its angle of inclination to the equator about 50 deg.

## Checks the ionospheric refraction

IB is being used mainly to check the ionospheric refraction effect on satellite transmitted signals. Four signals are being transmitted: 54 and 324 and 162 and 216 mc. Each frequency pair shares an oscillator. Their signals are radiated concurrently from a broad-band, logarithmic spiral antenna painted on the satellite's fiberglass shell. Each transmitter radiates about 100 mw.

All the electronics in Transit IB are transistorized. The entire package is mounted on a tray laced by nylon cord to the skin of the satellite. This method of suspension keeps the thermal conduction from the skin to the tray very low. In addition, a blanket that is about ⅛ in. thick and consists of alternate layers of aluminum foil and fiberglass filter paper shields the equipment.

Telemetered measurements show the skin temperature to vary from —10 to +150 deg F. The equipment section runs at 48 deg F, changing less than one degree per day.

The crystals for the IB's Colpitts oscillators are housed in double Dewar vacuum bottles that hang from the equipment tray by nylon cords. Measurements show that the crystal temperature changes less than 0.00001 deg F per day, providing a short-term frequency stability of better than one part in $10^9$. Kershner explains that the nearly perfect vacuum and vibration-free environment of space made this stability possible even with relatively simple equipment.

One of the most interesting features of the IB is its antenna, a double-spiral slot produced by spraying aluminum paint on the outer skin of the spherical satellite. The radiating fields are confined to the edges of the conducting surface. The polarization is essentially circular at the poles of the sphere and progresses through elliptical to linear at the sphere's equator.

As four frequencies are used, isolation networks had to be inserted in the RF coupling system. Both coupling and isolation networks use notch filters of open, quarter-wavelength stubs. About 30-db isolation is provided at each frequency.

## Two devices used for "de-spinning"

For the "de-spin" system, two devices are used. One consists of weights at the ends of two short cables. At first, the weights, are stowed between the solar cell banks around the sphere's midsection. When they are released on ground command, centrifugal force causes them to fly out to the full length of the cables, stopping most of the spin. Once in the full outstretched position, the weight pull out of their latches and drop off from the satellite. (If they didn't drop off, they would make the satellite spin in the reverse direction.)

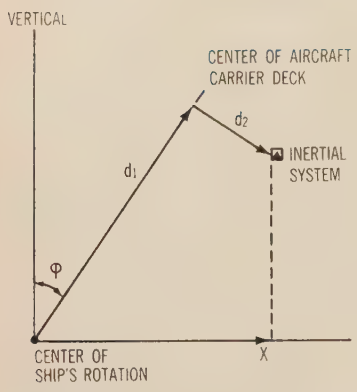
The second device is a magnetic brake, a device never before used in a satellite. It consists of eight small-diameter bars that are mounted crosswise in the satellite. The bars are made of nickel iron, a material with high magnetic permeability and a large hysteresis loss. Since they are in the earth's magnetic field, the bars become magnetized, and their high hysteresis opposes any reversals in the induced field, keeping the satellite aligned with the earth's field.

At launch, IB was spinning at 2.8 rps (for stabilization). The magnetic brakes slowed the spin down to 2.6 rps. After seven days of spinning, the weights were released and slowed the spin down to 0.04 rps. The further effect of the magnetic brake has now cut the spin down to 0.004 rps, reports APL.

For the operational system, 4-10 satellites will be sent up into criss-crossing orbits. Four, says APL, would provide a fix every 100 minutes over any place on earth.

APL scientists are looking into the use of Transit for aircraft navigation. The main problem is that, with its three-dimensional freedom and its high speed (which lets it cover a large distance during a pass of the satellite), an aircraft would have to carry fairly complex gear.

However, Kershner believes that Transit might make it possible for an aircraft using a relatively coarse navigation device to get very accurate latitude, longitude, and wind speed information.—End



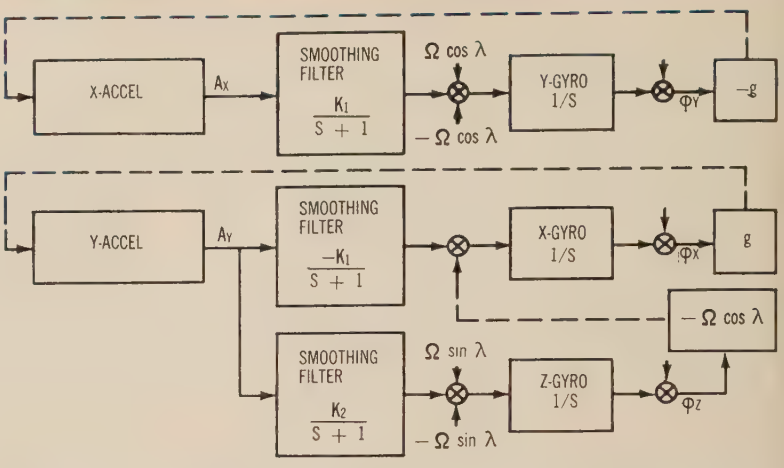




**FIGURE 1:** Vector diagram (left) used to define the location of the aircraft- or missile-borne, inertial system with respect to the ship's center of rotation. Right: Simplified block diagram of the functions of the fine-alignment mode. The dashed lines show the effects of gravity and the earth's rotation.

# Aligning intertial platforms at sea

**Not surprisingly, inertial platform alignment in shipborne aircraft or missiles is a good deal more involved than on land. However, as this report on platform alignment in carrier-based aircraft shows, essentially you design much the same systems for land-based and ship-based vehicles.**

**by Donald C. Martin,** Project Engineer, Guidance Systems Laboratory, Litton Industries, Inc.*

IN ALIGNING an inertial platform at sea, sea motion is the big problem—it causes the platform accelerometers to sense unwanted accelerations. Probably the best way to solve the problem is to use filters in the platform leveling and gyro-compassing loops. Obviously, the best filters are those with the call for a shortest alignment time.

Any motion of the sea-going vessel introduces acceleration signals in the alignment loop. For leveling, you want only gravity-derived signals, so all others must be filtered out. In a study of platform alignment on an aircraft carrier, we assumed that the carrier typically shows a 10-deg peak roll oscillation at 0.07 cps and a five-deg peak pitch oscillation at 0.1 cps.

If the platform is nearly level after the rough align-

* Litton Industries, Inc., 336 N. Foothill Rd., Beverly Hills, Calif.

ment (which involves caging the platform to the aircraft and aligning its Y-axis with north by magnetic compass), you need only consider the horizontal components of the undesired acceleration in your filter design. Therefore, you must determine the relationship between the flight-deck pitch and roll and the horizontal accelerations:

Locate the ship's center of rotation and the point at which the aircraft inertial system is being aligned (*Fig. 1*). You can then express the relationship of the horizontal accelerations to the amplitude of oscillation as:

$$X = d_1 \sin \phi + d_2 \cos \phi,$$

assuming that the angle of the ship's roll or pitch from the vertical ($\phi$) is:

$$\phi = \phi_M \sin \omega t,$$

where $\phi$ is maximum angle; $\omega$, angular frequency; and $t$, time.

Now substitute for $\sin \phi$ and $\cos \phi$ the equivalent expansion in terms of Bessel functions. If you assume that $\phi_M$ is small, neglect terms on the order of $\phi_M{}^3$ and higher, and differentiate $X$ twice, you get:

$$a_h = -\ddot{X} = \phi_M \omega^2 (d_1 \sin \omega t + \phi_M d_2 \cos \omega t),$$

where $a_h$ is the horizontal component of acceleration.

Assuming that the typical distance $d_1$ on an aircraft carrier is about 600 ft, $d_2$ might be 100 ft for roll and 500 ft for pitch. For a five-deg peak pitch oscillation at 0.1 cps and a 10-deg peak roll oscillation at 0.07 cps, you get:

$$a_h = 0.064 \sin 0.628t + 0.0465 \cos 1.256t,$$
$$a_h = 0.0628 \sin 0.44t + 0.0183 \cos 0.88t\ g,$$

for pitch and roll, respectively.

## Rough alignment is generally simple

If in rough alignment, the vehicle isn't level, neither is the platform. Usually, vehicle and carrier deck are in some roughly level attitude, so rough alignment can be done rather simply. For azimuth orientation, you slave the platform to the output of the vehicle's magnetic compass (in the case of an aircraft) to get a rough heading orientation.

The instant at which you switch from rough to fine alignment determines the magnitude of the initial misalignment error for the fine-align mode. This with your platform is caged to the aircraft, this error therefore is made up of the carrier's pitch and roll angles at the instant of switch-over. Generally speaking, the time needed for fine alignment depends directly on the magnitude of the coarse-alignment errors and the magnitude and frequency of the spurious acceleration forces to which the system is subjected.

In fine alignment, you use the platform accelerometers to get a level reference (*Fig. 1*). The X-accelerometer signal is applied to the X-axis gyro torquer, which precesses the gyro until the signal is nulled out. Similarly, the X-axis of the gyro is precessed until the signal from the Y-accelerometer is nulled out. The platform is now level.

The fine-align mode also establishes the correct azimuth orientation. By gyro-compassing, you line up the X-axis perpendicular to the velocity vector of the earth's

*more on next page*

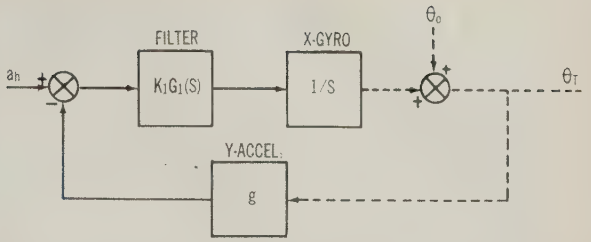



**FIGURE 2:** X-axis fine-leveling loop.

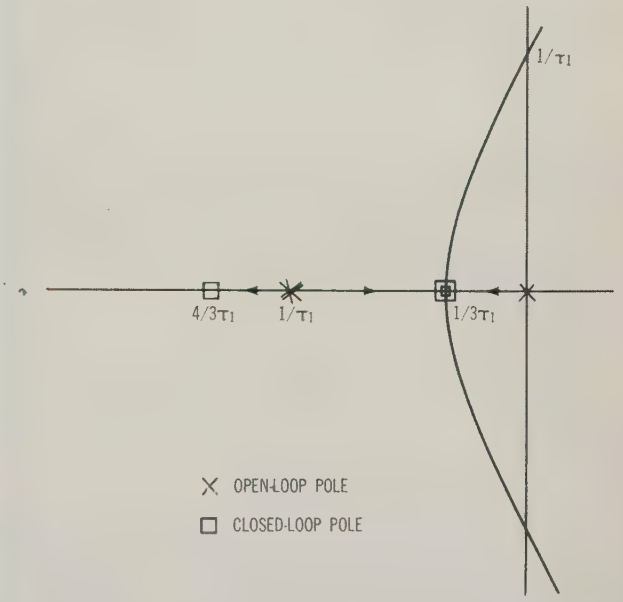



**FIGURE 3:** Leveling-loop root-locus plot for second-order filtering.

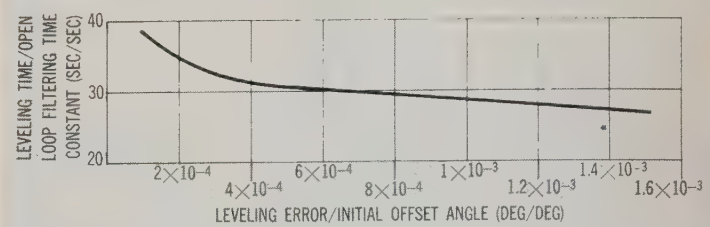



**FIGURE 4:** Leveling time vs leveling error due to the initial offset angle for optimum RC filtering.

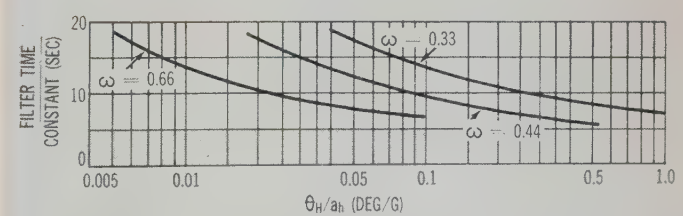



**FIGURE 5:** Leveling-loop noise for optimum second-order filtering, where $\theta_H$ is the angular disturbance due to $a_h$, the horizontal disturbing acceleration at angular frequency $\omega$ (in radians per second).

rotation. If the platform is accurately aligned in azimuth, the precession rate of the gyro X-axis is zero. If the azimuth alignment is off, a component of earth-rotation vector will be present, requiring a steady-state precessional velocity about the gyro X-axis to keep the Y-accelerometer level. The gyro X-axis torquing signal affords a measure of any azimuth misalignment, and is used to torque the gyro Z-axis until the platform is correctly aligned.

*Figure 2* shows the X-axis fine leveling loop. We can neglect cross-coupling terms, since they may reasonably be assumed to be quite small. If you design your filter properly, any initial offset angle ($\theta_o$) decays as quickly as possible (with minimum disturbance of the platform through carrier motion).

The first practical problem you face is: How complex should the filter be? If you increase the order of filtering, you cut the leveling time—for any fixed attenuation of the carrier's pitch- or roll-induced disturbances, a higher-order filter ups the dc gain. On the other hand, if you design a filter of more than second-order complexity, you usually must increase the weight, because of the difficulty of mechanizing the transfer function. Also, the shorter leveling time you achieve by going from a second- to a third-order system isn't worth the extra complexity.

For our level and gyro-compass loops, therefore, we considered only second-order filters. To get an idea of what some of the design requirements are, consider this second-order filter:

$$K_1 S_l(S) = K_1/(\tau_1 S + 1)^2.$$

*Figure 3* shows the root-locus diagram for the leveling loop using this filter. Keep in mind that the best filter is that which gives you critical damping of the alignment loop, since this effect minimizes the time for reducing any angular offset error to a given tolerance. Any higher gain would only amplify the disturbing influences of ship motion. *Figure 3* shows that the gain needed for critical damping is:

$$K_1 g = 4/27\tau_1^3.$$

Taking into account the angular error due to initial misalignment ($\theta_L$), the ship-motion error ($\theta_H$), and the total error ($\theta_T$), we can analyze the response of an alignment loop with a second-order filter whose gain is adjusted to give critical damping:

$$\theta_L/\theta_o = (119)\ [e(-4t/3\tau_1) + 4(t/\tau_1 + 2)\ e\ (-t/3\tau_1)]$$

*Figure 4* plots the transfer function for this loop configuration.

We can express the error due to ship motion as:

$$\theta_H/a_h = 4/27\tau_1 g(\tau_1 S - 1)^2 S + 4g,$$

where $a_h$ is the disturbing acceleration due to ship motion. *Figure 5* plots this transfer function for several values of frequency ($S = j\omega$).

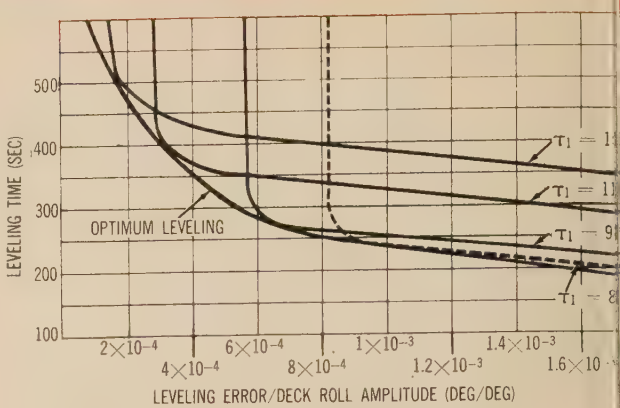



**FIGURE 6:** Second-order filtering at a roll frequency of 0.07 cps.

## NOMENCLATURE

| | |
|---|---|
| $a_h$ | disturbing acceleration due to ship's motion |
| $K_L$ | gyro-compassing loop gain |
| $K_1$, $K_2$ | filter gains |
| t | alignment time |
| $t_2$ | gyro-compassing time |
| $\theta_H$ | error due to carrier motion |
| $\theta_L$ | angular error due to initial misalignment |
| $\theta_T$ | total error |
| $\theta_0$ | initial misalignment |
| $\tau_1$ | optimum filter time constant |
| $\phi$ | angle of ship's roll or pitch from the vertical |
| $\phi_L$ | error due to initial misalignment |
| $\phi_{L1}$ | offset error around the gyro X-axis caused to initial misalignment angle at start of gyro-compassing |
| $\phi_M$ | maximum angle of ship's roll or pitch from the vertical |
| $\phi_T$ | total level error |
| $\phi_X$, $\phi_Y$, $\phi_Z$ | angular misalignment of the platform |
| $\phi_{X0}$, $\phi_{Y0}$, $\phi_{Z0}$ | initial angular misalignment |
| $\phi_i$ | initial conditions at the start of gyro-compassing |
| $\psi_H$ | ratio of carrier-induced disturbance |
| $\psi_L$ | azimuth offset angle |
| $\psi_i$ | initial misalignment around the gyro Z-axis |
| $\omega$ | angular frequency of ship's roll or pitch from the vertical |

## Best $\tau_1$, align time for roll angle

From *Figures 4 & 5*, we can now determine the best filter time constant ($\tau_1$) and alignment time interval for a given maximum roll angle. From what we know about the relationship between the flight deck's pitch and roll and the horizontal accelerations, we can derive an expression for the fundamental roll mode:

$$a_h/\phi_c = 0.00628,$$

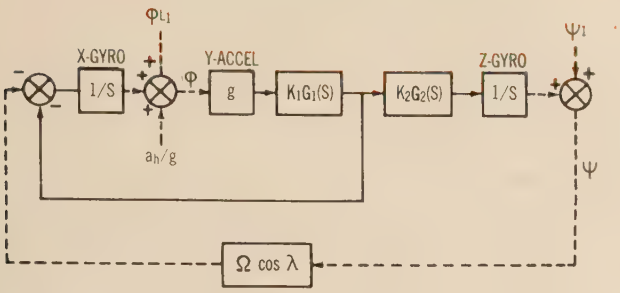
where $\phi_c$ is the amplitude of deck roll. The RMS value is:

$$0.00628/\sqrt{2} = 4.44 \times 10^{-3}.$$

The probable total error ($\theta_T$) at $t$, caused by both an initial alignment error and ship motion, is:

$$\theta_T/\phi_c = \sqrt{(\theta_L/\theta_o)^2 + (4.44 \times 10^{-3}\theta_H/a_h)^2}.$$

*Figure 6* plots $\theta_T/\phi_C$ vs leveling time (for several values of $\tau_1$ for a second-order filter and critical damping) as well as an optimum level of filtering. To see how you can use these curves, assume a maximum roll of 17.5 deg and a final leveling error of $57.3 \times 10^{-3}$ deg. You find that the best filter under these conditions



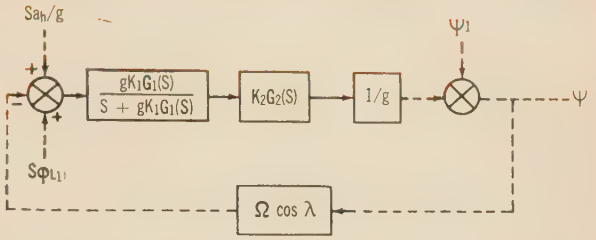




**FIGURE 7:** Block diagrams of the leveling-to-gyro-compassing loops (above) and the gyro-compassing loop itself (above right).

would require a time constant of 11.6 seconds, and that the alignment time would be 400 seconds. Obviously, the alignment time can't be optimum for every sea state. Using the same filter for a roll angle of only 3.5 deg, you would get a leveling time of 295 seconds, whereas the optimum would be 200 seconds.

## Loop gain can change with latitude

*Figure 7* shows the gyrocompassing loop. For this loop the transfer functions are:

$$\psi/a_h = SK_1K_2G_1(S)G_2(S)/F(S),$$
$$\psi/\psi_I = S(S + gK_1G_1(S)/F(S),$$
$$\psi/\phi_I = SgK_1K_2G_1(S)G_2(S)/F(S),$$

where $\psi_I$ and $\phi_I$ are initial platform conditions at the start of the gyro-compassing phase, and:

$$F(S) = S^2 + SgK_1G_1(S) + gK_1K_2G_1(S)G_2(S)\Omega \cos \lambda.$$

*Figure 8* shows that the loop gain changes with latitude, provide the other gains ($K_1$ and $K_2$), are held constant:

$$K_L = K_1K_2g\Omega \cos \lambda.$$

$K_2$ can be adjusted to compensate for the latitude gain change: in the navigation computer, make $K_2$ a function of the secant of latitude. The gyro-compassing loop now can be assumed to have critical damping at all latitudes.

To prove the soundness of this design, you can run through the following problem:

- As quickly as possible, a given platform is to be aligned to a level state, and its probable error is to be reduced to 0.1 mil. How much leveling time is required for carrier rolls of various amplitudes?
- After leveling, gyro-compass the platform at a 45-deg latitude so that the probable azimuth error reduces to one mil in the shortest possible time. Assume an initial azimuth misalignment of five degrees and that the carrier is heading either east or west. (This represents the worst case, with all roll disturbances impinging on the X-gyro torquing rates rather than applying components to both the X- and Y-gyros.) How

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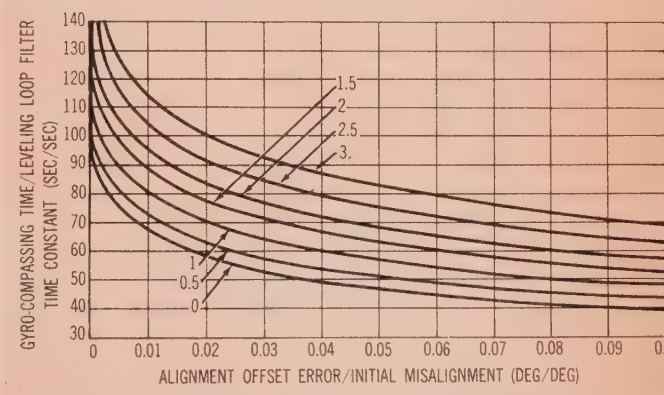



**FIGURE 8:** Second-order filtering in the leveling and gyro-compassing loops at various values of $\tau_2/\tau_1$.

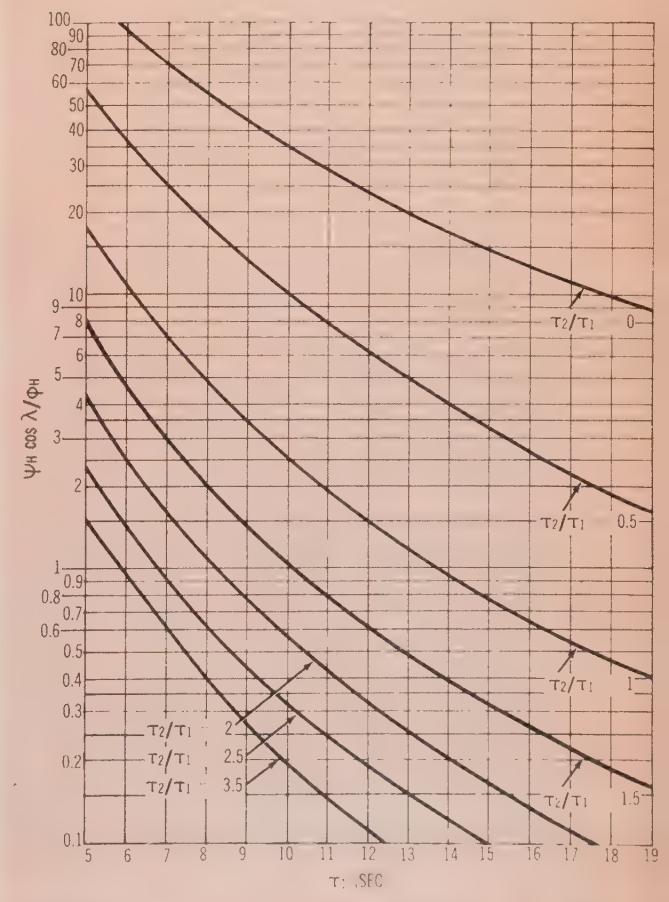
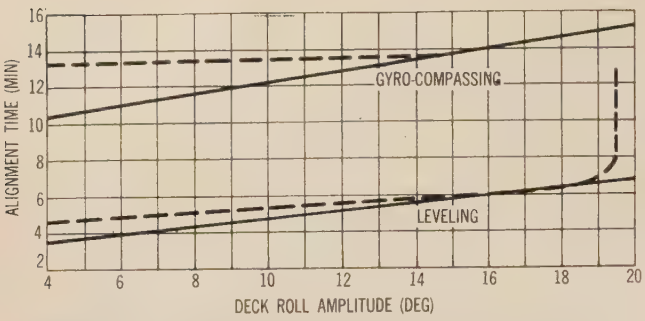



**FIGURE 9:** Leveling and gyro-compassing loop filters $[(\tau_1 S - 1)^{-2}]$.



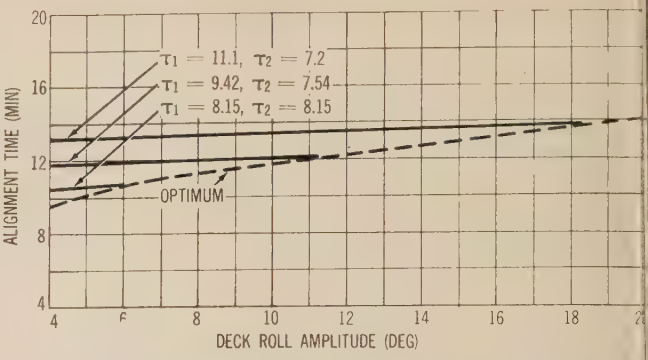




**FIGURE 11:** Alignment times for 0.1-mil leveling and one-mil gyro-compassing accuracies and the fastest possible leveling and gyro-compassing (left, solid curves), $\tau_1 =$ 11.1 and $\tau_2 = 7.2$ (left, dashed curves), and a leveling accuracy of 0.1 mil at the end of gyro-compassing (right).

much gyro-compassing time is needed at various amplitudes of deck roll?

As in the alignment loop, we are using second-order filtering in the gyro-compass loop. An iterative process can be used to solve the timing problem. Two families of curves are plotted: one for ratios of gyro-compassing time ($t_2$) to leveling-loop filter time constants ($\tau_1$) as a function of the ratio of azimuth offset angle ($\psi_L$ at $t_2$) to initial azimuth misalignment (*Fig. 8*); the other for ratios of carrier-induced disturbances in $\psi$ to those in $\phi$ (normalized for latitude) as a function of $\tau_I$ (*Fig. 9*). The curves in *Figure 8* are found by solving for the closed-loop poles, the required gain, and the residues at the dominant double pole.

Next, plot a family of curves for alignment time vs carrier deck roll amplitudes for various filter designs:

- Assume a particular amplitude of deck roll and calculate the RMS value of the horizontal disturbing acceleration caused by the ship's motion.
- Assume values for input frequency and filter time constant and find the corresponding value of $\theta_H/a_H$ from *Figure 5*.
- Calculate the error due to ship motion.
- Assume a total level error, and calculate the error due to initial misalignment ($\phi_L$) from:

$$\phi_T = \sqrt{\phi_H^2 + \phi_L^2}.$$

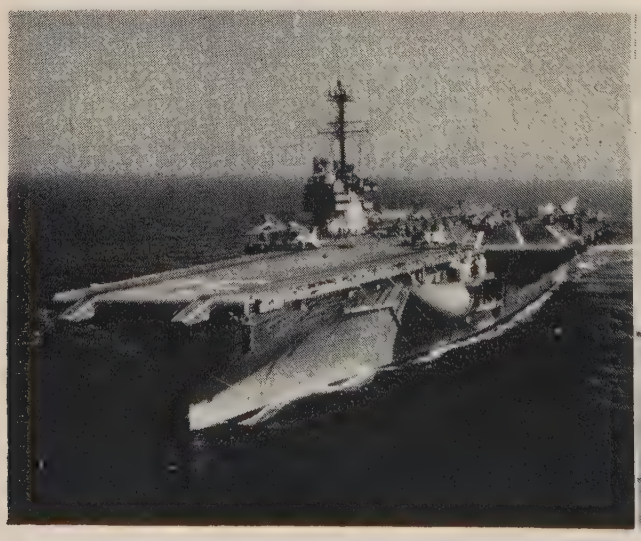
- Calculate $\phi_L/\phi o$.
- Find the value of $t_1\ \tau_1$ from *Figure 4*.
- Calculate $t_1$.
- Find the value of $\Psi_H \cos \lambda/\phi_H$ from *Figure 8*, and calculate $\psi_H$.
- Assume a total gyro-compassing error, and calculate $\psi_L$.
- Assume an azimuth offset error, and calculate $\psi_L/\psi_1$.

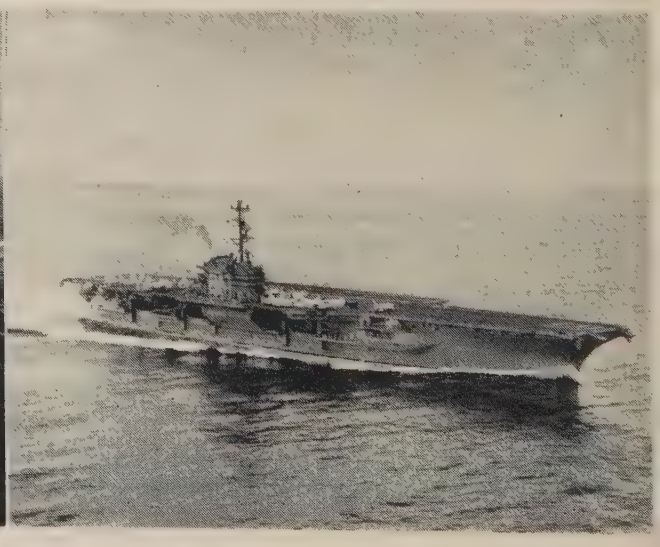
Find $t_2/\tau_1$ from *Figure 8*.

- Calculate $t_2$.

*Figure 10* gives the answers to our problem for 0.1-

**EVEN** smooth sailing can pose rough problems for the alignment of inertial platforms on shipborne vehicles. Any motion of the ship causes the platform accelerometers to respond and sends unwanted signals into the alignment loop. The carriers shown here are the Ranger and the Independence.





mil leveling and one-mil gyro-compassing accuracies and for the fastest possible leveling of $\phi_T$ and for the reduction of $\phi_H$ to 0.1 mil.

Since the gyro-compassing takes more time than the leveling, it should be started as early as possible. We must, therefore, study the effect on the gyro-compassing loop of an initial X-axis misalignment ($\phi_{L1}$) at the time of switchover from leveling.

The right time to start gyro-compassing depends on the magnitude of the residual offset error ($\psi_L$) at the end of gyro-compassing, rather than on the peak value of the transient or torquing rate limits caused by imperfect leveling. *Figure 11* plots the ratios of $\psi_L$ due $\phi_{L1}$ to $\psi_L$ (initial Z-axis misalignment) for various values of $\tau_2/\tau_1$ vs $t_2/\tau_1$ on the basis of the equations for $\psi_L/\psi_1$ and $\psi_L/\phi_{L1}$. The combination of $\phi_{L1}$ to $\psi_L$ can be found from *Figures 4 & 11*.

## Best switching time, $\tau_1$, $\tau_2$ found

By an iterative process, you can now find the optimum switching time and the time constants $\tau_1$ and $\tau_2$. For example, assume a 20-deg deck roll, a leveling accuracy of 0.1 mil, and a gyro-compassing accuracy of one mil. *Figure 5* shows that $\tau_1$ equals 11.4 seconds at the required leveling accuracy. If we further assume that $\tau_2/\tau_1$ equals 0.7, we get, from *Figure 9:*

$$(\psi_H/\phi_H)\cos\lambda = 3.8.$$

Therefore, $\psi_H$ equals 0.537 mil. For $t_2/\tau_1 = 78$, we get, from *Figure 8:*

$$\psi_L/\psi_1 = 8 \times 10^{-4}.$$

For a five-degree initial azimuth misalignment, this gives us:

$$\psi_L = 8 \times 10^{-4} \times 5 \times 1000/57.3 = 0.7 \text{ mil.}$$

For a total azimuth accuracy of one mil, we get:

$$(\psi_L/\phi_{L_1})\phi_{L_1}/(\psi_L/\psi_1)\psi_1 = \sqrt{(1 - 0.7^2 - 0.537^2)/0.7} = 0.68.$$

From *Figure 11*, we get:

$$(\psi_L/\phi_{L_1})/(\psi_L/\psi_1) = 1125/11.4 = 98.7.$$

Now, we can find the RMS value for the error at the start of gyro-compassing:

$$\phi_{L_1} = 0.68/98.7 \times 5 = 0.0244 \text{ deg RMS.}$$

However:

$$\phi_{L_0} = 20/\sqrt{2} = 14.14 \text{ deg RMS.}$$

Therefore:

$$\phi_{L_1}/\phi_{L_0} = 0.00243.$$

*Figure 5* shows that $t_1$ equals 25.7. The time required for leveling only therefore is:

$$25.7 \times 11.4/60 = 4.88 \text{ minutes.}$$

The combined gyro-compassing and leveling time needed to reach an accuracy of one mil is:

$$78 \times 11.4/60 = 14.8 \text{ minutes.}$$

By varying $\tau_2/\tau_1$ and $t_2/\tau_1$, you can find the minimum overall alignment time for any particular sea-state. *Figure 12* shows both this alignment time and the best time to start gyro-compassing for various amplitudes of deck roll to attain 0.2-mil leveling and two-mil azimuth accuracies, as well as the required filter time constants and dc gains.

Our analysis clearly shows that simple second-order filtering is adequate in even the worst sea-states. This conclusion has been proved in actual tests on the high seas aboard an aircraft carrier.—End

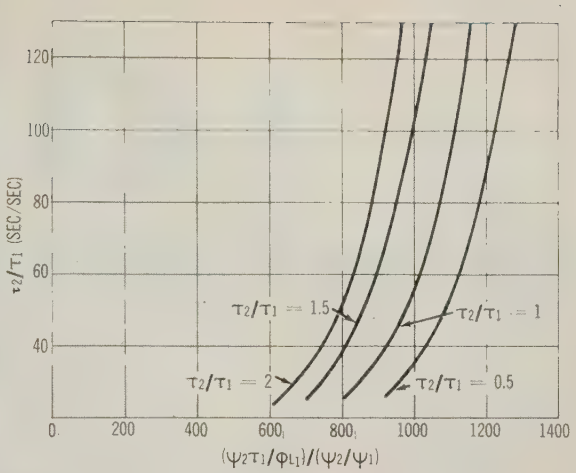
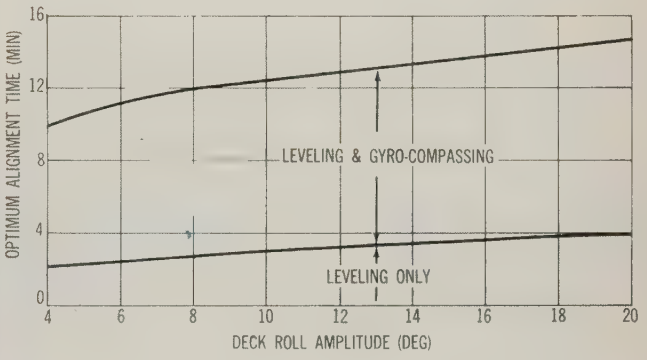
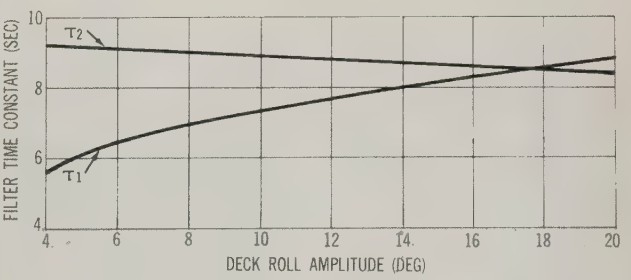



**FIGURE 11:** Normalized ratio of azimuth responses to level and azimuth misalignments at the start of gyro-compassing.



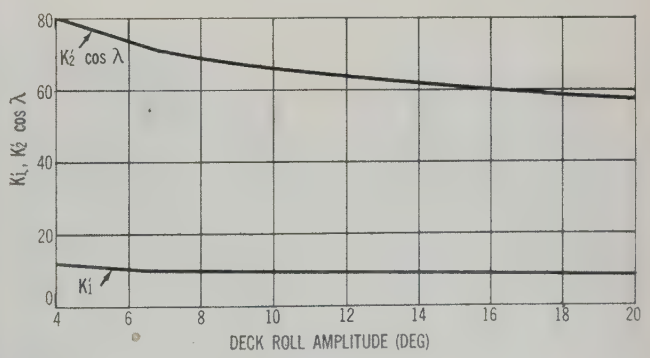




**FIGURE 12:** Optimum alignment times vs deck roll amplitude and the required filter time constants and dc gains.

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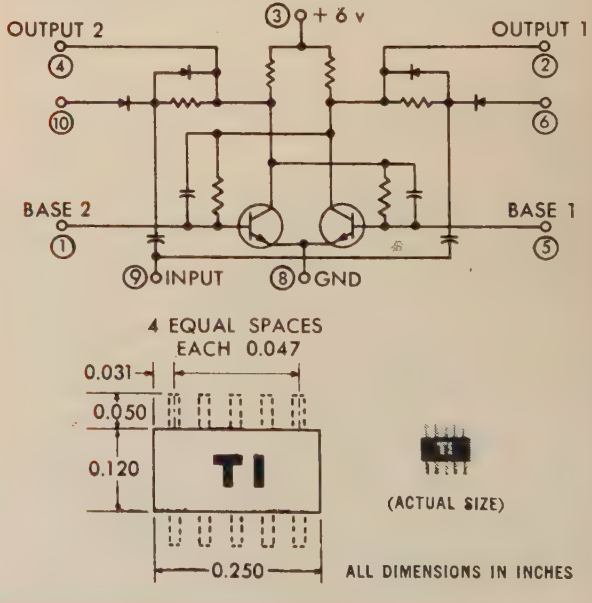


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# Jetliner's tail cap makes best HF antenna

by Bernard Kovit
Associate Electronics Editor

OF THE EIGHTEEN antenna systems built into the DC-8 by Santa Monica Div., Douglas Aircraft Corp., Santa Monica, Calif., probably the most difficult to design was the HF antenna. The critical drag and weight limits imposed by the plane's Mach 0.85 cruise speed ruled out the long-wire HF devices used in the DC-6 and -7. Various shunt- and series-fed, flush and semi-flush antennas also were found lacking. The real answer, Douglas engineers concluded, was an integral antenna formed by insulating a part of the vertical fin from the rest of the aircraft. By means of antenna transfer relays, this single low-impedance antenna is switched between dual HF transmitter-receiver systems. An integrated dual tuning system is used that reportedly handles 1000 W peak effective power over the entire 2-25-mc range. A rugged lighting arrestor is installed within the insulation gap. According to Douglas, the power transfer and radiation efficiencies of the HF antenna in the tail fin easily meet Mil spec A-9080.

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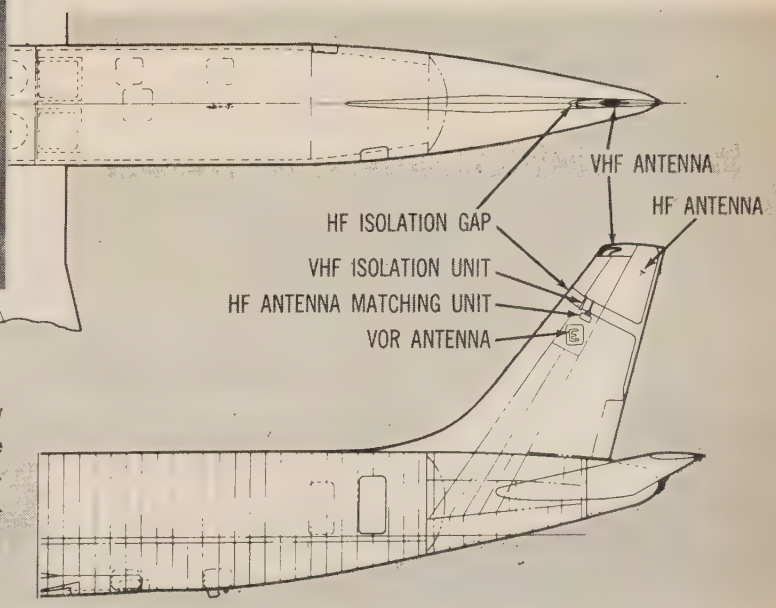
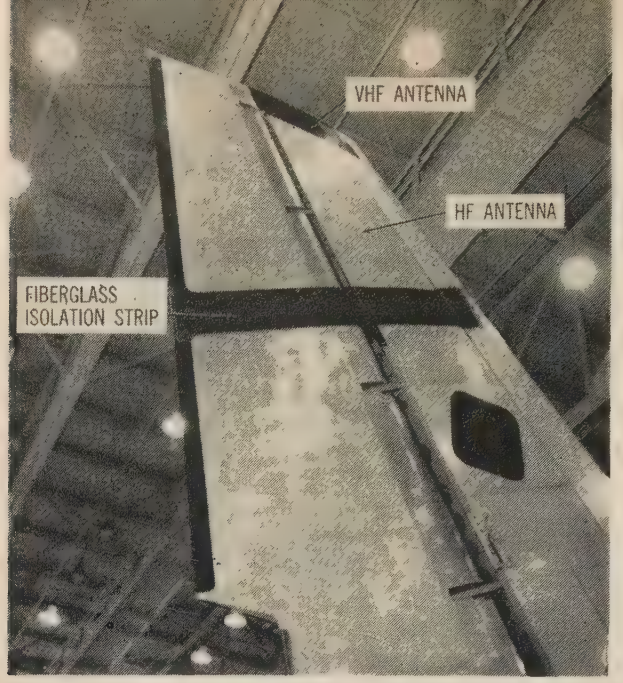
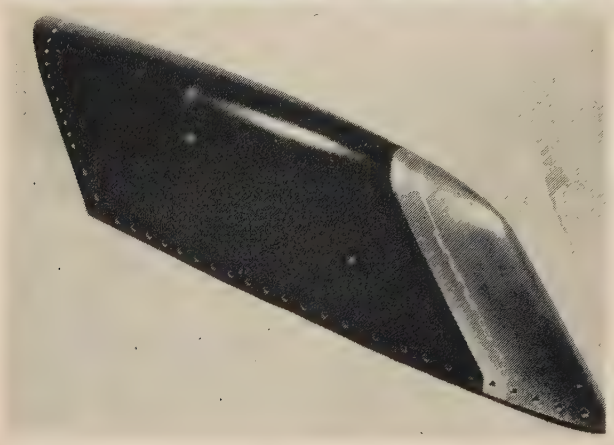


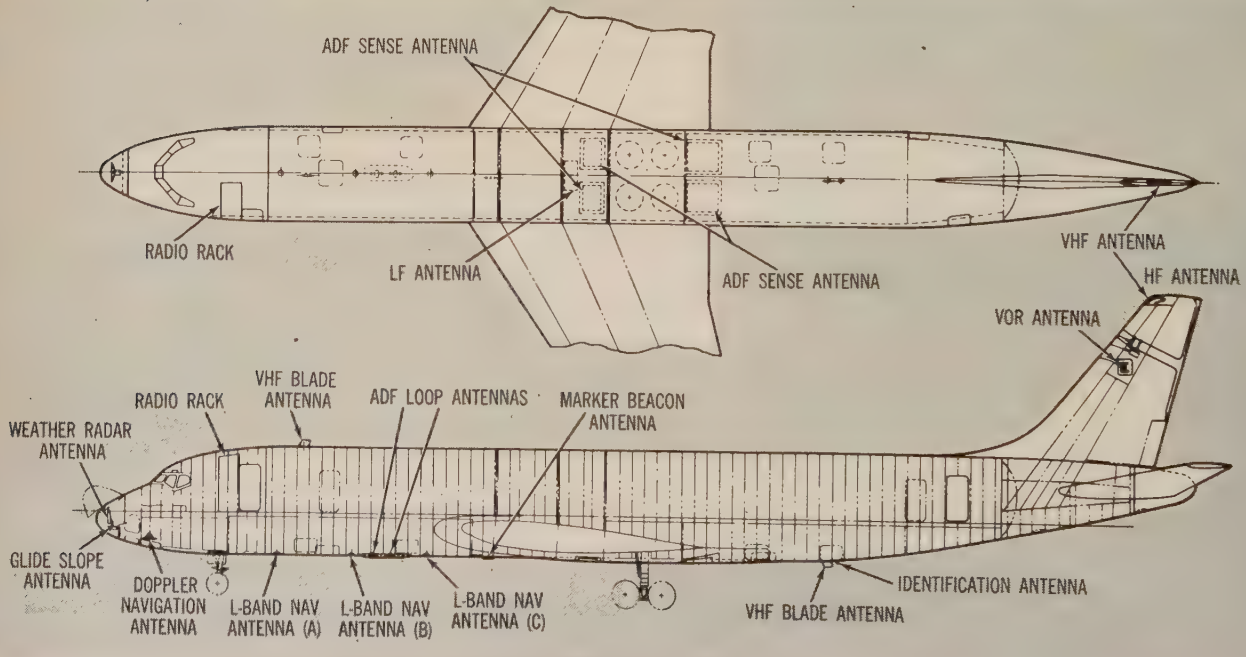

TAIL SECTION details show how the tail cap antennas are made part of the tail structure. The isolation strip is an epoxy-resin-laminated fiber-glass structure.

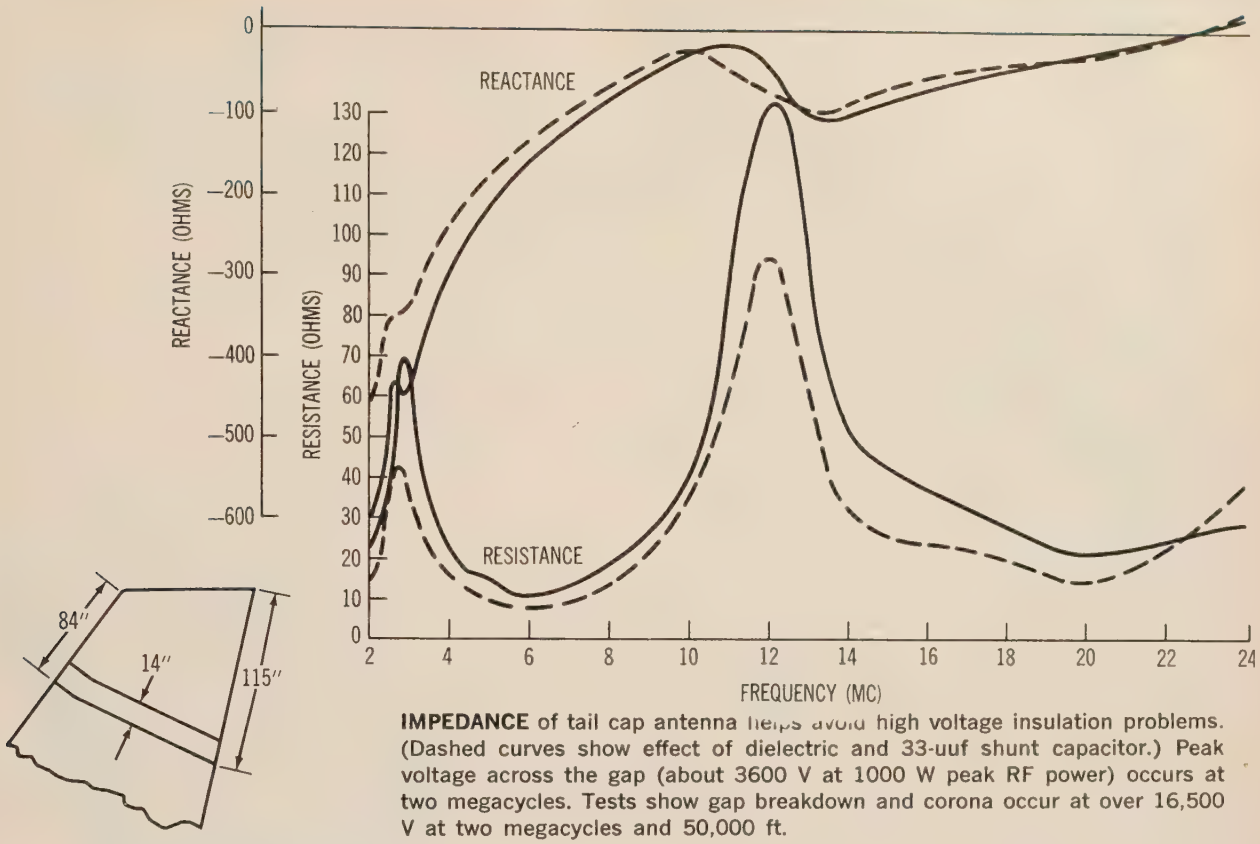


**HF TAIL CAP ANTENNA** (left) forms an integral part of the DC-8's vertical fin. Shared by a dual system of transmitter-receivers and tuners, it is used to excite various portions of the airframe. Actually, at certain frequencies, the whole airframe acts as the antenna. Douglas found that the only practical way to tune the tail cap antenna was to mount the reactive elements of the tuners near the antenna feed point. All tuner components (receiver couplers and coupler accessory units, antenna transfer relays, impedance matching units, servo amplifiers, etc.) and a rugged lightning arrestor as well were designed as an integrated system by Collins Radio. The VHF antenna is a 12-in.-high aluminum-fiberglass airfoil section (lower left). Within it, a one-inch-diameter aluminum tube is attached to the aluminum leading edge to form a dc path to ground. A Rantec isolation unit (below), made up of two balanced resonant loops enclosed in an evacuated glass tube, transfers RF signals by mutual inductance to and from the VHF antenna across the HF isolation gap.

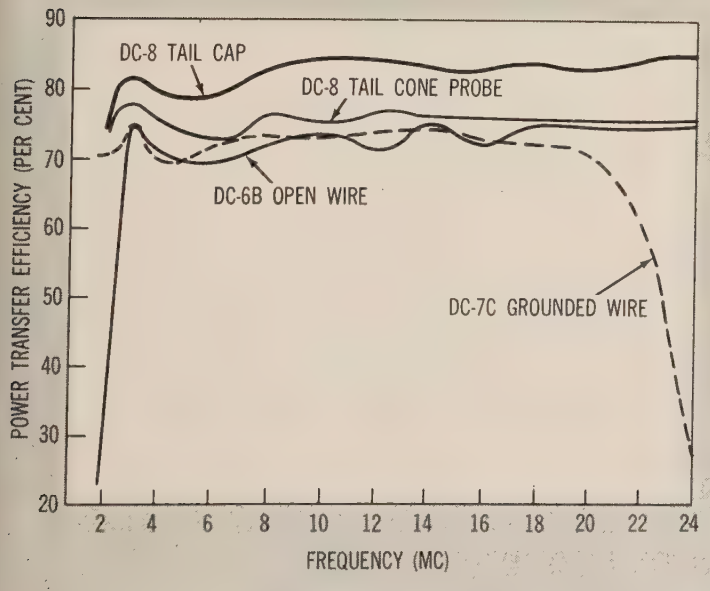
**FULL** antenna complement for the DC-8 includes 18 basic systems. Since the DC-8 has to be an aerodynamically "clean" ship, flush antennas were preferred. The DC-8 antenna design reportedly started in 1952.

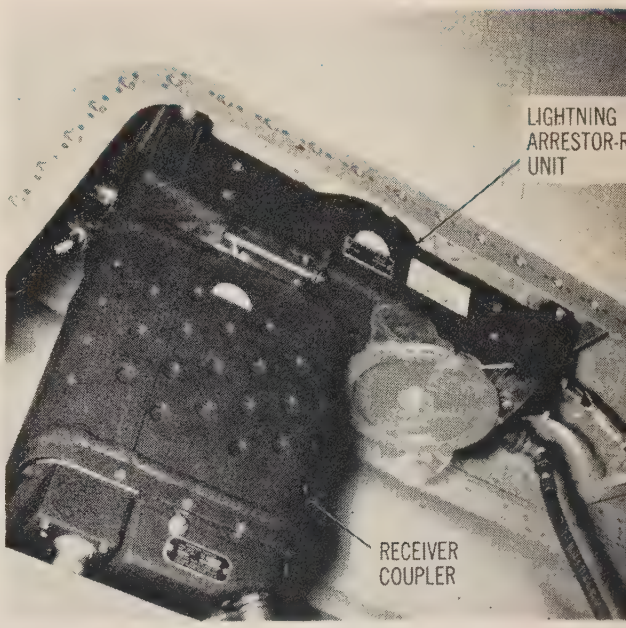





**IMPEDANCE** of tail cap antenna helps avoid high voltage insulation problems. (Dashed curves show effect of dielectric and 33-uuf shunt capacitor.) Peak voltage across the gap (about 3600 V at 1000 W peak RF power) occurs at two megacycles. Tests show gap breakdown and corona occur at over 16,500 V at two megacycles and 50,000 ft.

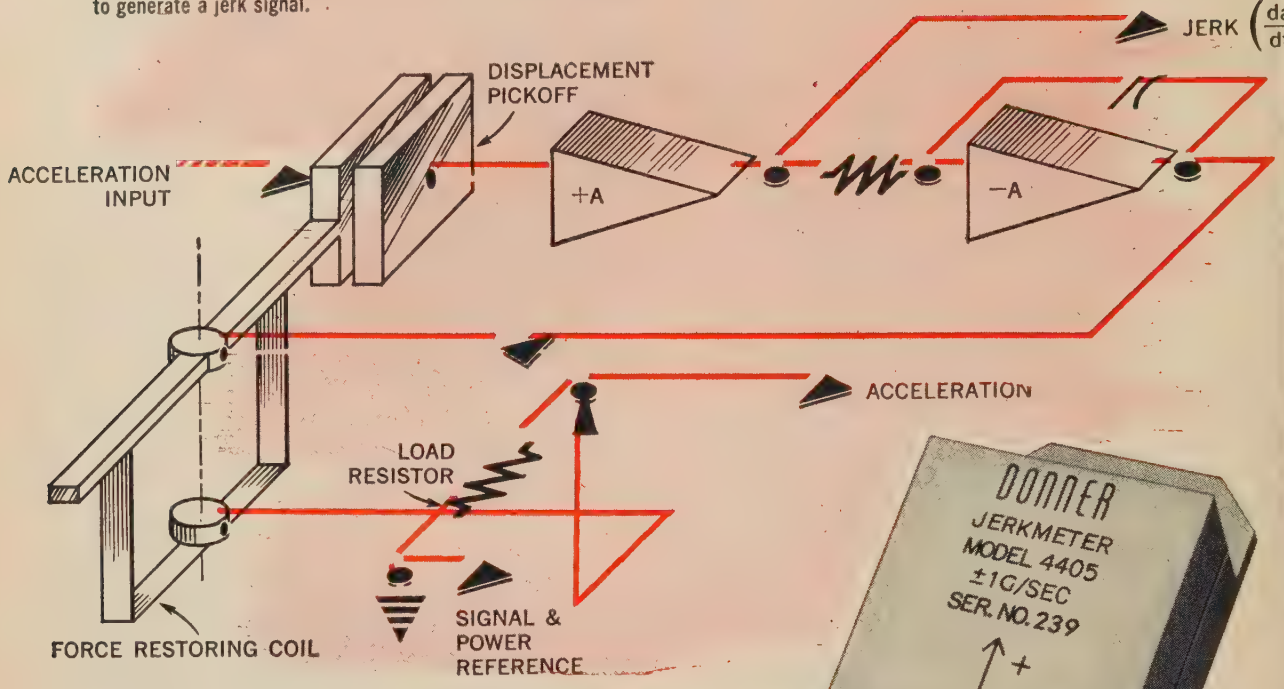
**POWER TRANSFER** efficiency of tail cap antenna, 15-ft-long tail cone, and DC-6 and -7 antennas.



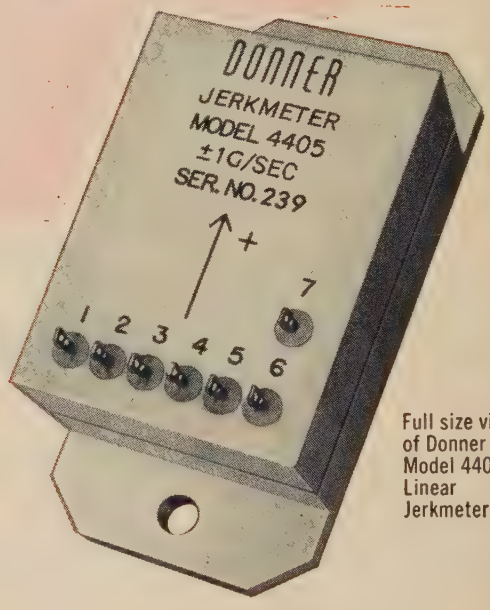




**TUNER**—Since lightning arrestor-relay unit and both couplers are individually pressurized, system operates with one coupler out. Arrestor, set to flash over at under 14,000 V, extends into insulated zone.

Functional diagram of Donner Linear Jerkmeter. This unique instrument operates as a subminiature servo-system of the force-balance type which is responsive to jerk along the sensitivity axis of the linear unit and about the sensitive axis of the angular unit. Basically, the system consists of a transistorized accelerometer with an integrator inserted into the servo-loop to generate a jerk signal.




# HOW TO MEASURE $\frac{da}{dt}$




Full size vie of Donner Model 4405 Linear Jerkmeter

## *New Donner precision Jerkmeters measure linear and angular jerk to ±0.5% or better.*

If your measurement and control problem requires accurate measurement of jerk or the rate of change of acceleration, Donner Scientific's new line of precision angular and linear jerkmeters can help.

These new instruments are the only truly accurate device of this type ever made. They are designed to meet the most demanding applications. Both angular and linear jerkmeters provide an output voltage proportional to jerk which in turn can be used to instigate compensatory control forces or other actions. *An acce eration analog output voltage is also available.*

Typically, a jerkmeter installed in a jet aircraft will provide a instantaneous output proportional to the rate of change of g' This signal can be used to predict impending disaster condition

Other applications include use wherever constant acceleratio is required. Here, the Donner jerkmeter provides a "velocity damping" term. The jerkmeter also provides a third order ter for stabilizing displacement devices. It can also be used as a inertial indicator of first motion.

KEY SPECIFICATIONS for Model 4405 Linear Jerkmeter

RANGES
Acceleration: ±1 g full range to ±30 g full range
Jerk: ±0.5 g/sec full range to ±20 g/sec full range

OUTPUT FULL SCALE
Accelerometer: ±7.5 v dc
Jerk: ±7.5 v dc

RESOLUTION
0.1% full scale or better

LINEARITY
0.1% full scale or better

HYSTERESIS
Less than 0.1%

POWER
+15 v dc at 10 ma and −15v dc at 10 ma

SIZE
3" long, 1½" wide, 1⅝" high

WEIGHT
7.5 ounces

**WANT MORE INFORMATION?** *The new Donner Jerkmeter is another product from a firm specializing in the manufacture of accurate fixed and general purpose analog systems designed to analyze, measure, and control inputs interlocking time, acceleration, jerk, velocity, and other dynamic inputs. Complete technical information can be obtained by calling your nearby Donner engineering sales representative or writing Dept. 103*

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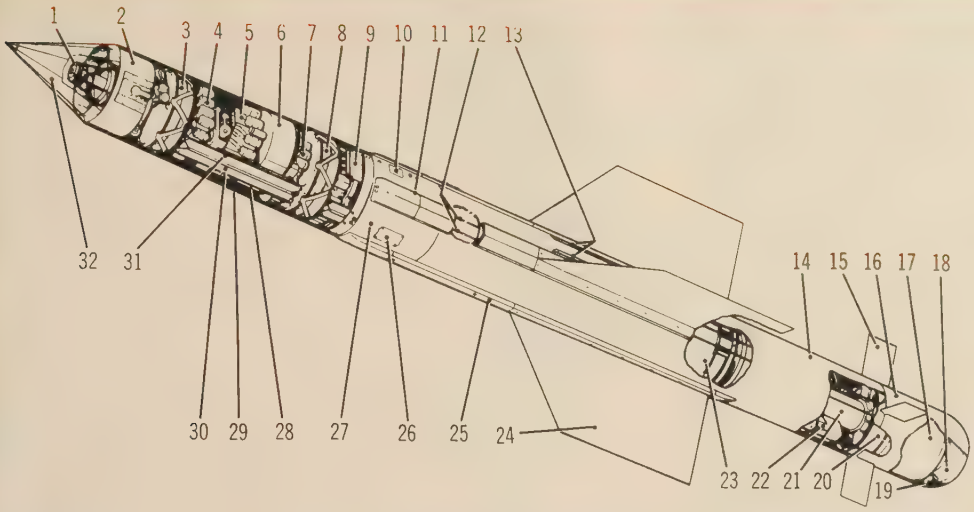


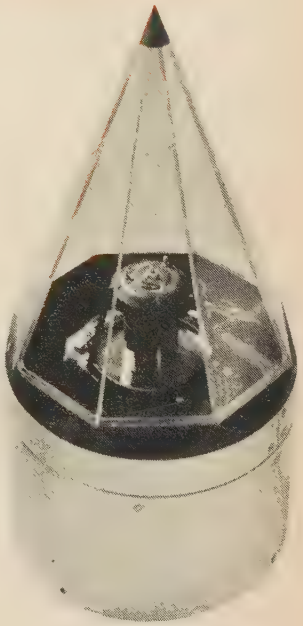

**INTERIOR** layout of Firestreak (left) features miniaturization and compact arrangements: (1) telescope, (2) guidance homing head, (3) front fuze assembly, (4) guidance electronics, (5) control electronics, (6) rate gyro unit, (7) fuze electronics, (8) rear fuze assembly, (9) power pack, (10) services plug, (11) actuator assembly, (12) control rods, (13) feet, (14) rear body tube, (15) control surface, (16) boat tail, (17) air bottle, (18) blast pipe cone, (19) bottle charging valve, (20) control casting, (21) blast pipe, (22) initiator, (23) motor, (24) wing, (25) front fairing, (26) monitoring points cover, (27) actuator casting, (28) rotary converter, (29) front body skin, (30) side rail, (31) heat exchanger, (32) glass nose. Printed circuits and encapsulated modules are used in the electronics. Right: Pointed nose of eight triangles of optical glass houses the folded optics, scanner, and detector that make the IR guidance system.

# Firestreak

## is guided by advanced IR homer

**Here is a report on the guidance and control electronics of the de Havilland Firesteak air-to-air missile, claimed to be far superior to the U. S. Navy's Sidewinder against maneuvering targets and 50 per cent more likely to score a kill.**

**by Christopher Dawson,** Associate Editor*

FIRESTREAK, now in service with the Royal Air Force and Royal Navy, is Britain's first operational air-to-air guided missile. It was designed as an infrared-homing short range weapon small and light enough so that two or four of the missiles could be carried (underslung) by a fighter.

The warhead, though reportedly larger than that of any other air-to-air weapon, is small enough to demand accurate guidance and proximity fuzing. For both these functions, infrared (IR) systems are used.

The Firestreak, designed by de Havilland Propellers Ltd., Hatfield, Herts, is cruciform in configuration, has

* This article is based in part on a lecture given by G. H. P. Brown before the Bristol Branch, Royal Aeronautical Society, on Feb. 17, 1960.

*more on next page*

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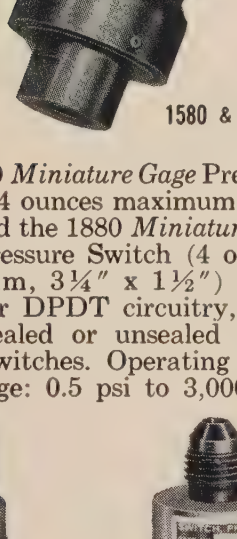

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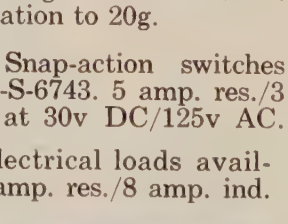

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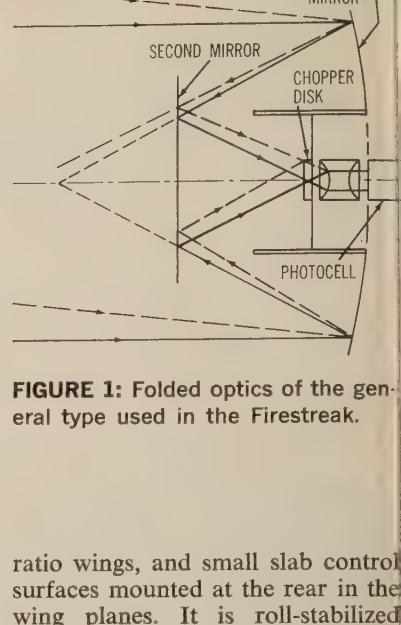



**FIGURE 1:** Folded optics of the general type used in the Firestreak.

ratio wings, and small slab control surfaces mounted at the rear in the wing planes. It is roll-stabilized and controlled in pitch and yaw.

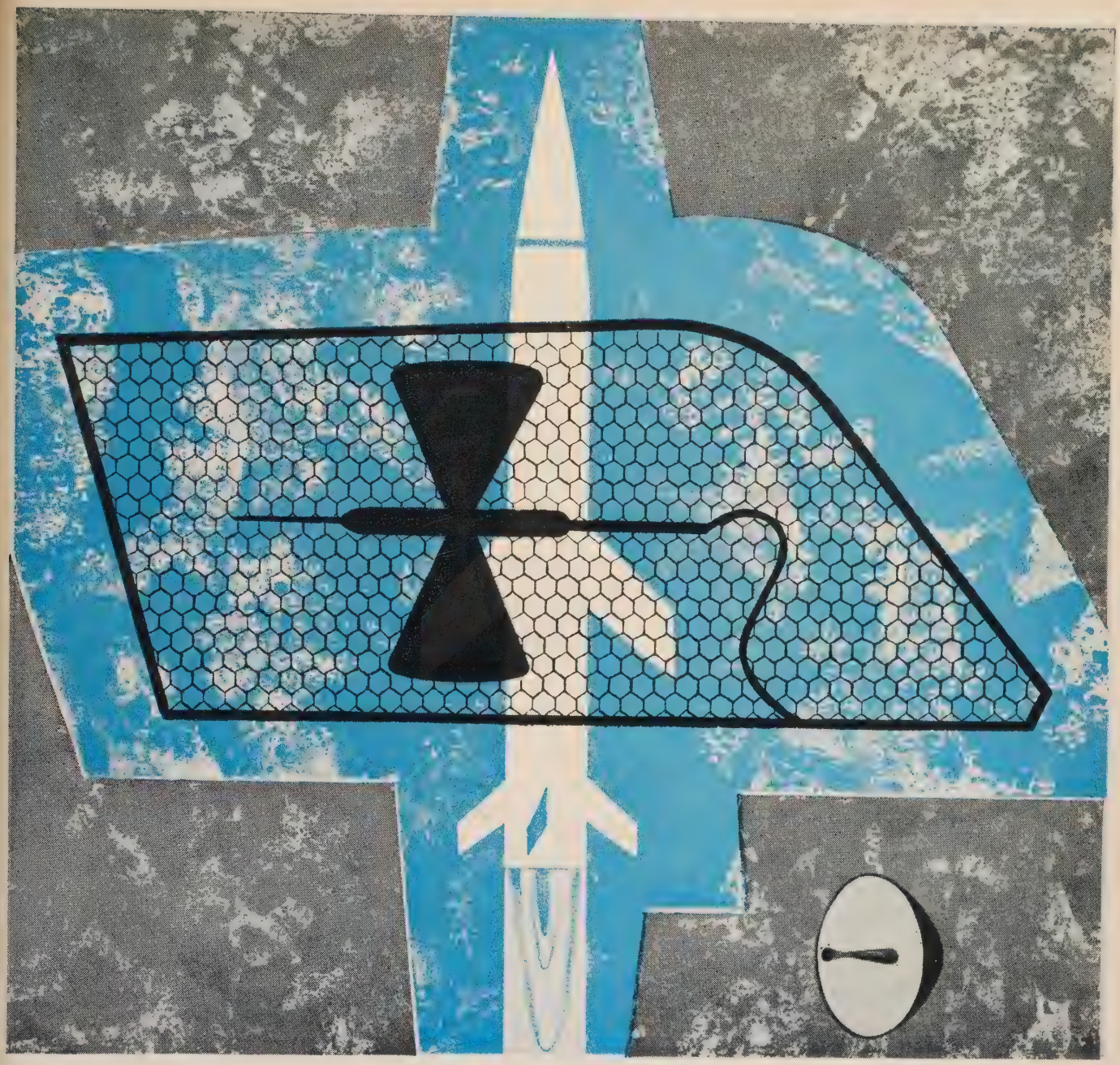
As the incident energy of jet aircraft—the Firestreak's expected targets—lies in the intermediate part of the IR spectrum (around 2.5-6.5 microns), the guidance is built around a detector cell responsive to energy in this band and insensitive to the shorter wavelength radiation from the sun. The design of the irdome was particularly troublesome. Kinetic heating makes the nose of high speed missiles a source of IR radiations. If the speed is high enough, these radiations will be in a band that can interfere with the emissions from the target. "Nose-heating" therefore limits the top speed of an IR-guided missile.

To combine high speeds and a "cool" irdome, Firestreak's designers came up with a flat-faceted, pointed irdome shape. According to de Havilland's test data, the Firestreak irdome is cooler, under given aerodynamic conditions, than a hemispherical irdome like the Sidewinder's. Another advantage of the pointed shape is that it greatly reduces icing.

De Havilland admits, however, that these advantages have to be paid for in optical aberrations and manufacturing complexity. One headache was finding an adhesive to hold the irdome's eight triangular optical glass plates together under all operating conditions.

The Firestreak's short range makes it possible to use a small collection mirror to gather incident IR energy for guidance. This mir-

more on page 172



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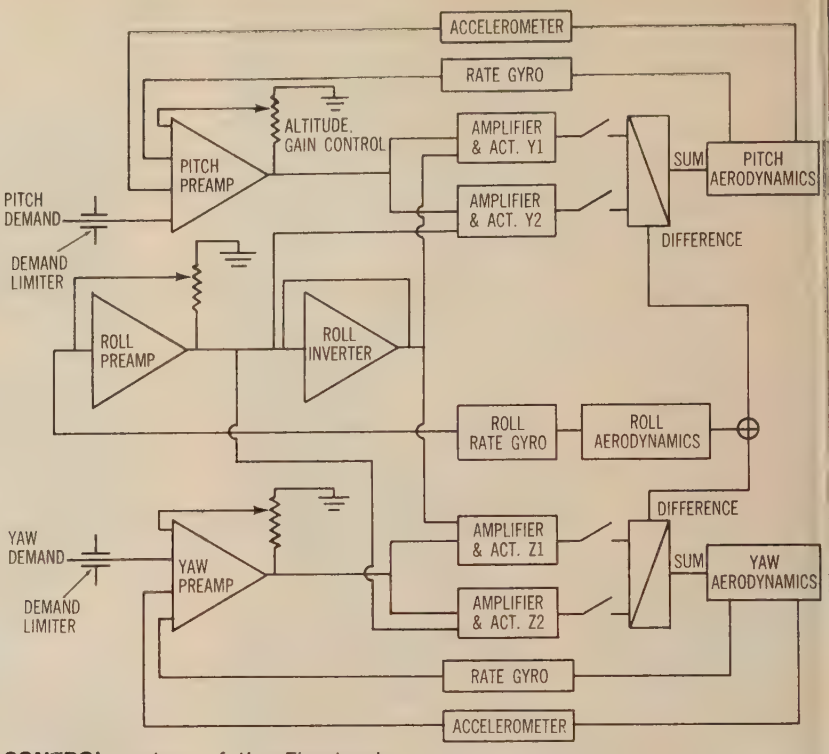



**CONTROL** system of the Firestreak.

ror determines the size of the homing head and so the scale of the entire missile.

Folded optics are used in the seeker (*Fig. 1*). Incident energy is collected on a concave mirror, reflected forward to another mirror, and back again through an aperture on the axis of the optical system, and through a chopper (a rotating reticle) to a photoelectric cell. Both chopper and detector cell are housed in a cylinder measuring about 1½ in. in diameter. The telescope-chopper-cell assembly mounts directly behind the homing head in a gimbal ring that allows a wide viewing angle from the missile axis.

The collected IR energy is frequency-modulated by the spinning-reticle-type chopper. The reticle serves two purposes:

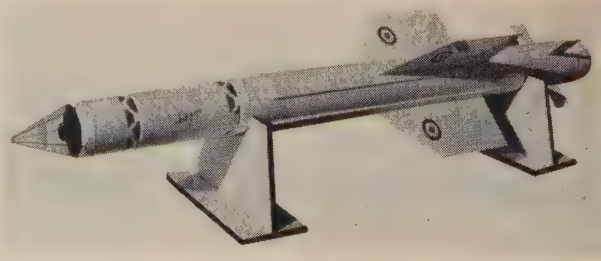
- it makes it possible to amplify the signal at a frequency that is relatively free from system noise;
- it provides directional information.

*Figure 2* shows how the chopper disk works. The output frequency is a measure of the radial distance from the chopper disk axis to the spot of focused infrared radiation. This distance is a function of the angle between the line of sight to the target and the optical axis. The optical head locks on to the target only when the gimbal is aligned so that the output signal frequency is at a minimum or zero.

The number of concentric rings on the chopper disk—and therefore the number of frequency steps—can be made as large as necessary to provide a smooth error curve. The optical error signal is used to demand gyro precession torques. Since the gyro is mounted on the same gimbal as the optical unit, the error signal gives the off-

*more on page 174*

**CRUCIFORM** controls and pointed nose are distinctive features of de Havilland's 125.55 - in. - long, 8.75 - in. - diameter, 29.4 - in. - span Firestreak air-to-air missile.



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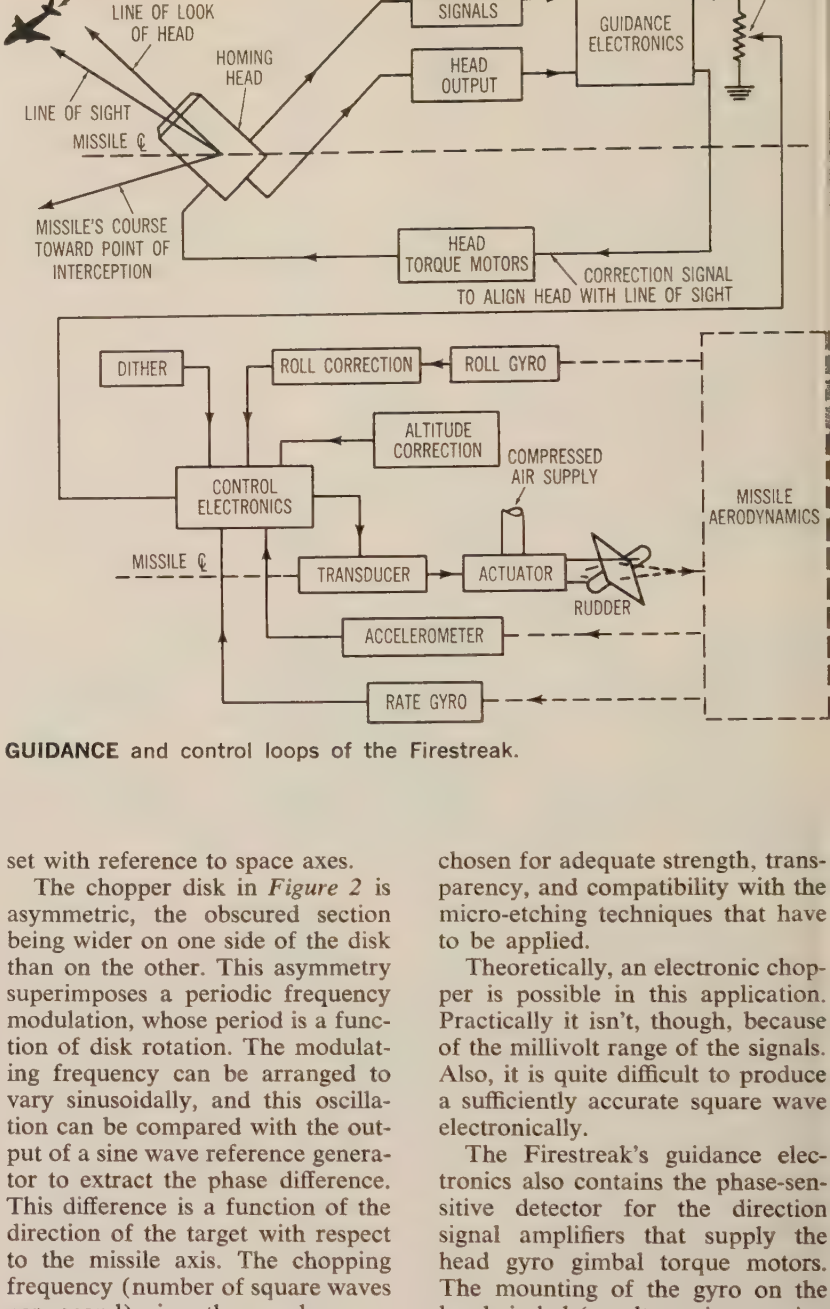


**GUIDANCE** and control loops of the Firestreak.

set with reference to space axes.

The chopper disk in *Figure 2* is asymmetric, the obscured section being wider on one side of the disk than on the other. This asymmetry superimposes a periodic frequency modulation, whose period is a function of disk rotation. The modulating frequency can be arranged to vary sinusoidally, and this oscillation can be compared with the output of a sine wave reference generator to extract the phase difference. This difference is a function of the direction of the target with respect to the missile axis. The chopping frequency (number of square waves per second) gives the angular error of the target relative to the gyro spin or optical axis (i.e., the angle in space), and the phase difference gives the angular deviation of the target from the missile axis.

## Low noise amplification must be ensured

When you design a chopper for an FM system, the basic frequency must be high enough for low noise amplification. However, the speed of rotation—which determines the frequency—is limited by stress and bearing life to a few hundred rps. The chopper materials must be chosen for adequate strength, transparency, and compatibility with the micro-etching techniques that have to be applied.

Theoretically, an electronic chopper is possible in this application. Practically it isn't, though, because of the millivolt range of the signals. Also, it is quite difficult to produce a sufficiently accurate square wave electronically.

The Firestreak's guidance electronics also contains the phase-sensitive detector for the direction signal amplifiers that supply the head gyro gimbal torque motors. The mounting of the gyro on the head gimbal (an alternative to using a space gyro driving the head through a servo loop) results in high gimbal inertia. High roll rates therefore must be avoided, particularly at large head deflections. It's for this reason mainly that the Firestreak uses cruciform dynamics rather than a twist-and-steer system.

The advantages of the directly mounted gyro are simpler design, compactness, and lower cost. Also, the gyro precession torques give a measure of the components of the line-of-sight spin, which are used in the proportional-line-of-sight

more on page 177



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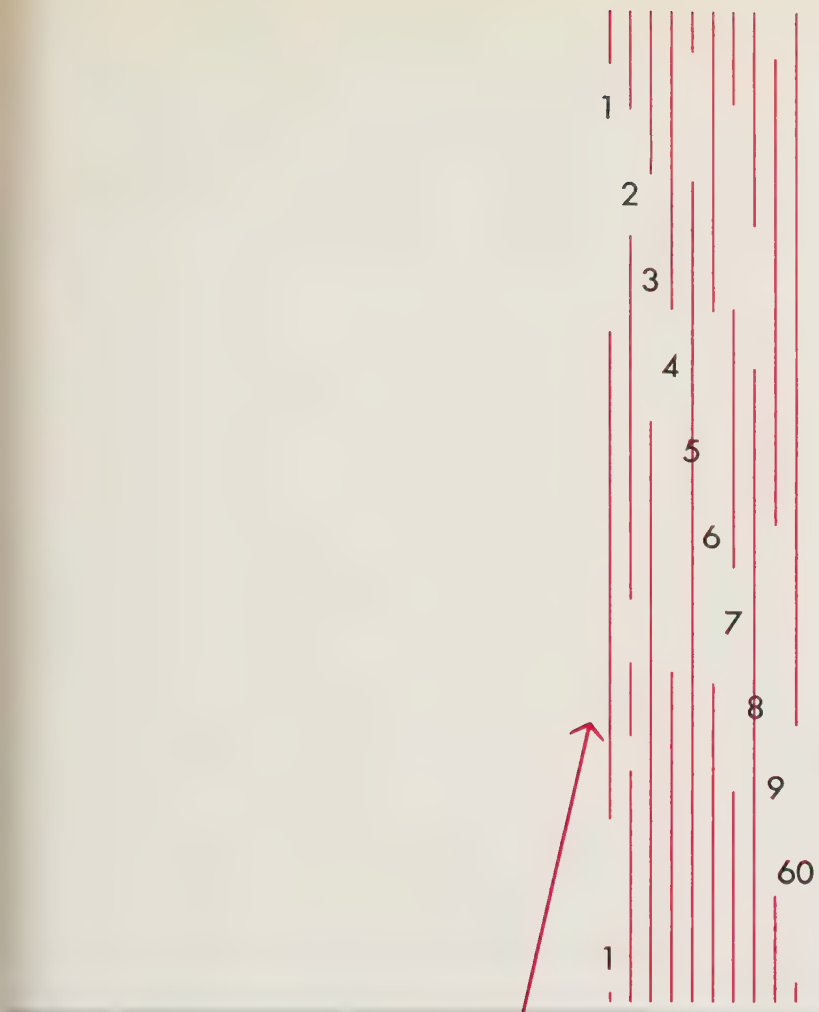
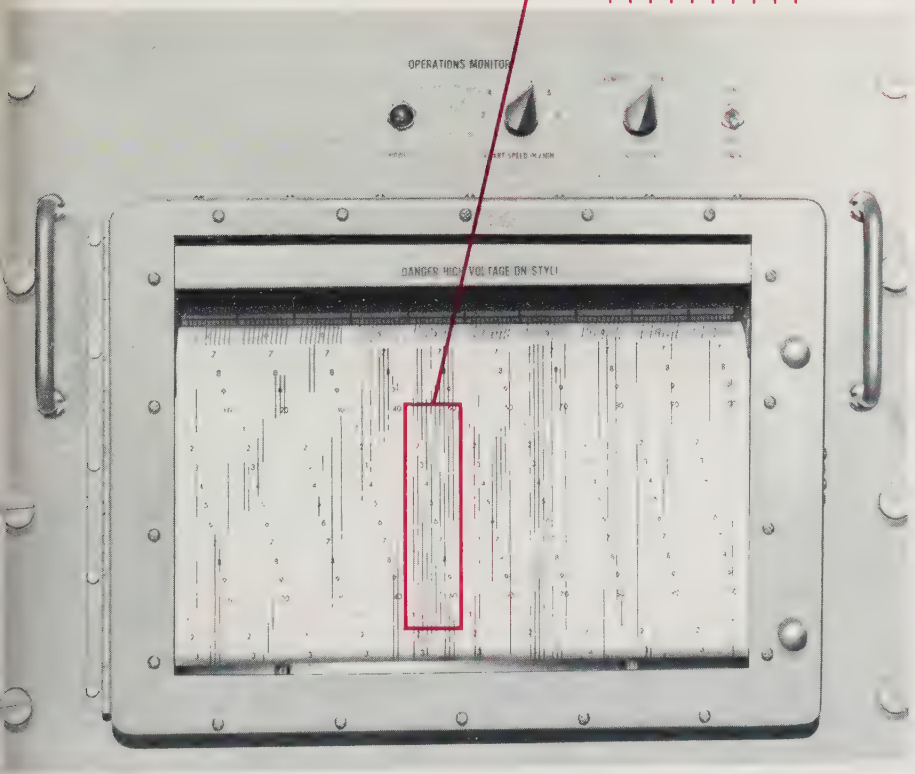



# insight at 4 milliseconds

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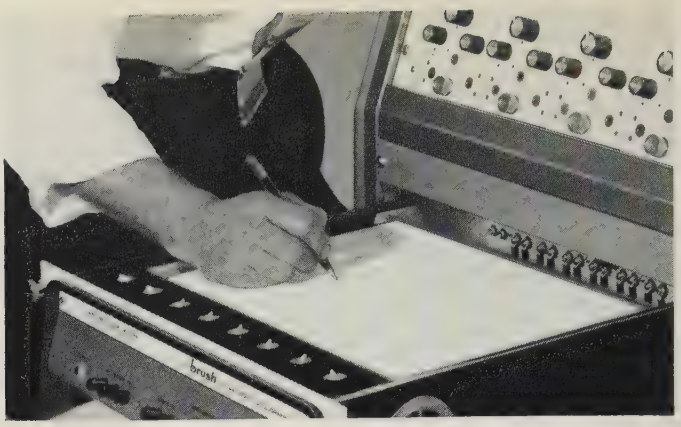

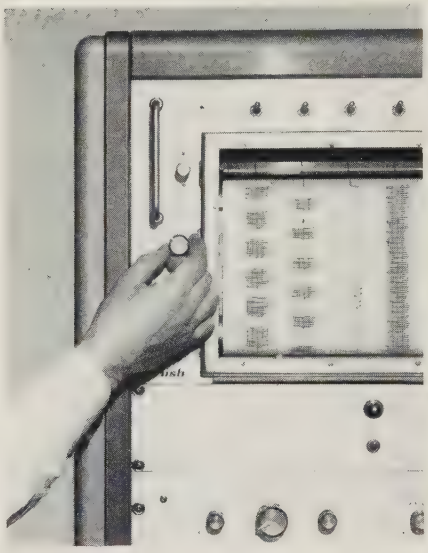

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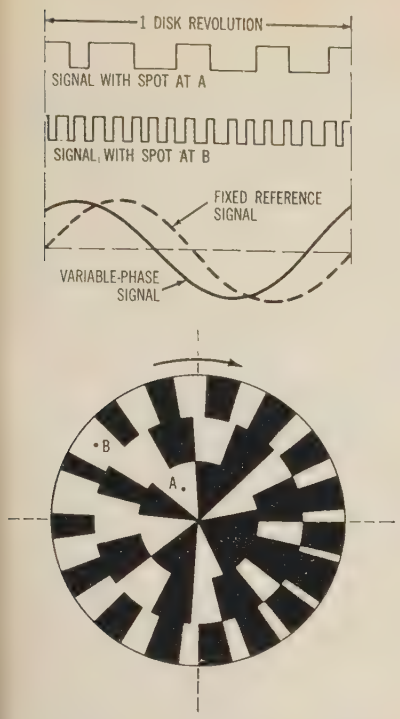



**FIGURE 2:** Simplified scanning disk for a frequency-modulated IR homer. Output signals are square waves whose period varies sinusoidally. The output frequency (number of square waves per disk revolution) varies directly with the radial distance of the incoming signal from the center of the disk.

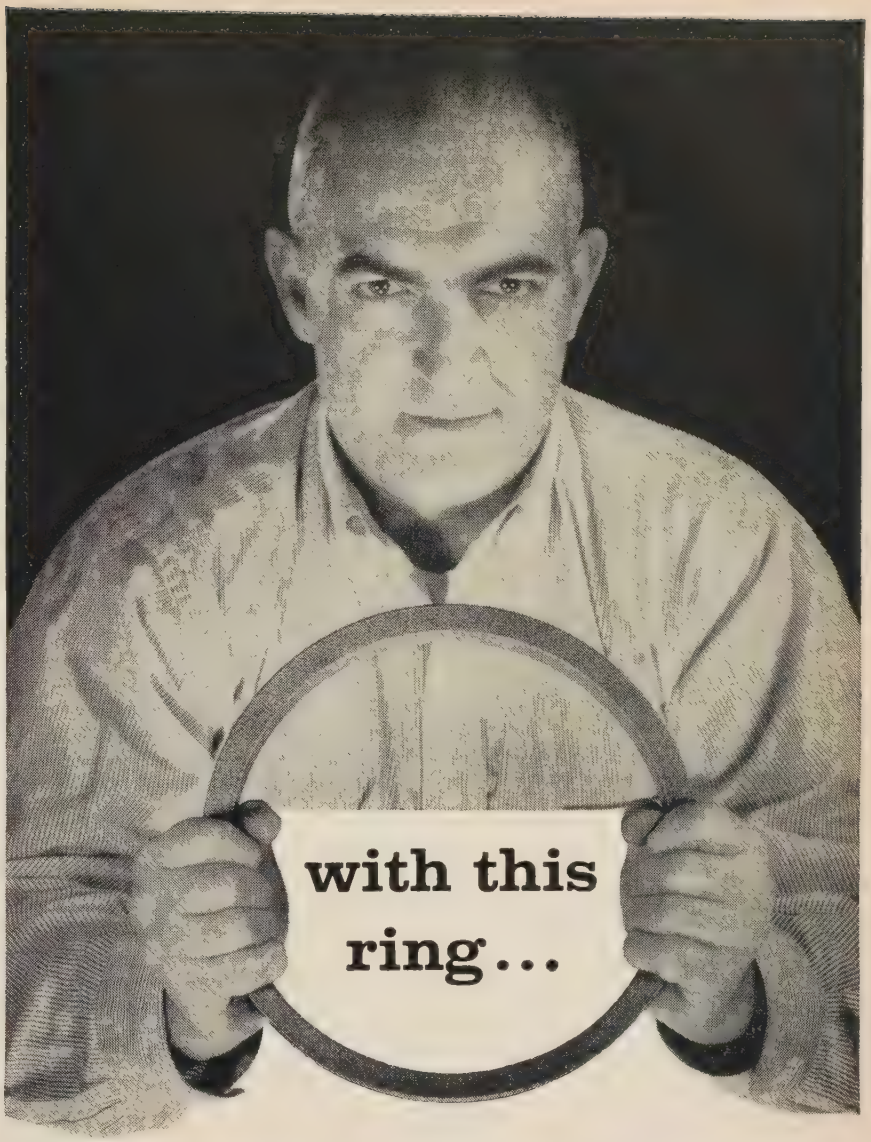
navigation system that guides the missile to its target.

The main advantage of the frequency modulation is the absence of noise when a signal is being received. De Havilland was able to design the Firestreak's control system for rapid response that provides accurate steering signals to within close range of the target. A drawback of the FM system is the complex chopper design.

The Firestreak is designed for high-g maneuvering. As a result, it is sensitive to spurious demand signals arising from gimbal bearing friction and optical aberrations. These errors, together with others caused by out-of-balance forces in the guidance system, were reduced by careful engineering design and development.

Standing oscillations occur in some flight conditions, but they haven't proved serious, according to de Havilland. Damping to overcome gyro nutation is provided by

*more on next page*




**the perfect match** Edgewater Steel has the engineering experience, the manufacturing facilities and the know-how to produce solid steel rings that match perfectly the requirements of a wide variety of applications.

**long-term reliability** Our unique rolling process assures maximum reliability in terms of strength and toughness. What's more, the precise accuracy of this process minimizes finishing operations.

**Edgewater ROLLED STEEL Rings** Complete, modern rolling and finishing facilities enable us to provide a great variety of cross-section shapes in a wide range of sizes . . . from 5 in. to 145 in. in diameter. Our brochure gives complete details. We will be glad to send you a copy.

**Edgewater Steel Company**
P. O. BOX 478 DEPT. SA
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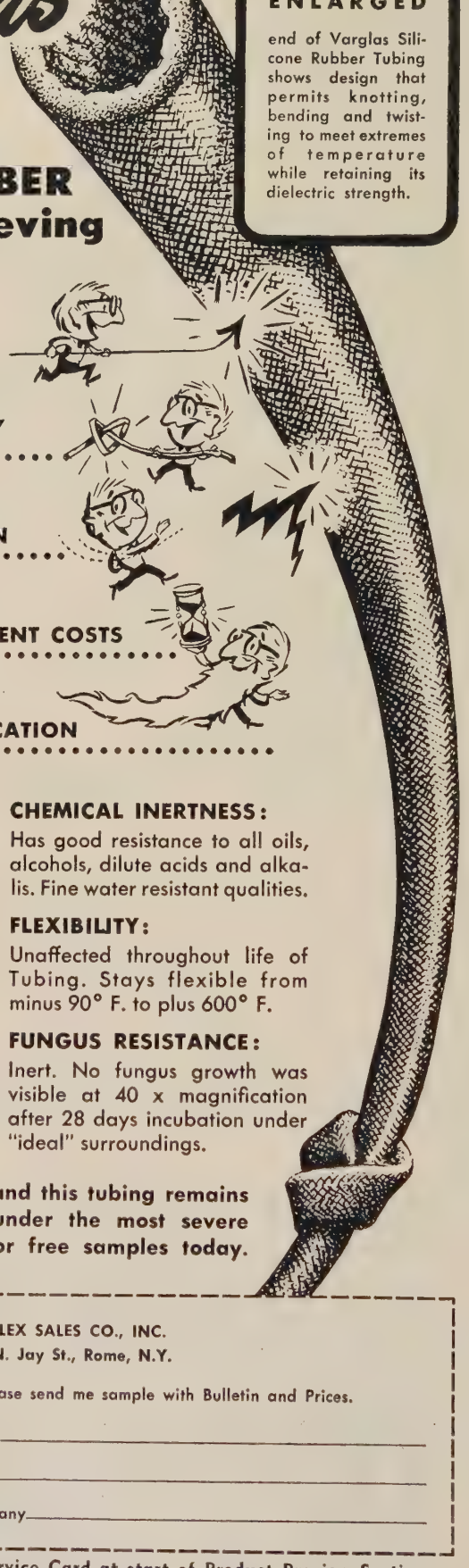
# 5 Ways Better...

## Varglas

**SILICONE RUBBER**
**Tubing and Sleeving**



**GREATLY ENLARGED**

end of Varglas Silicone Rubber Tubing shows design that permits knotting, bending and twisting to meet extremes of temperature while retaining its dielectric strength.

1. WON'T CRACK, PEEL OR CRAZE
2. GREATER FLEXIBILITY
3. HIGH DIELECTRIC RETENTION
4. LONG LIFE CUTS REPLACEMENT COSTS
5. VIVID COLORS FOR READY IDENTIFICATION

**THERMAL PROPERTIES:**
Heat aging: 1000 hrs. at 250° C without appreciable change in physical or dielectric properties.

**FLAMMABILITY:**
Self-extinguishing, when tested in accordance with ASTM and NEMA procedures. (NEMA Acceptance Test).

**ABRASION RESISTANCE:**
Durable and extra tough. Withstands unusual rough handling at all times.

**CHEMICAL INERTNESS:**
Has good resistance to all oils, alcohols, dilute acids and alkalis. Fine water resistant qualities.

**FLEXIBILITY:**
Unaffected throughout life of Tubing. Stays flexible from minus 90° F. to plus 600° F.

**FUNGUS RESISTANCE:**
Inert. No fungus growth was visible at 40 x magnification after 28 days incubation under "ideal" surroundings.

**Twist, bend, wrap or knot it and this tubing remains pliable and efficient, even under the most severe operating conditions. Send for free samples today.**

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SPECIALISTS
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VARFLEX SALES CO., INC.
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Please send me sample with Bulletin and Prices.

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a zero-gain loop at the critical frequency.

Guidance signals are fed to the control system via a potentiometer that varies the ratio of flight path turn rate (or control angle) to sight-line spin. This "*k*-factor" is equivalent to the closed-loop gain in a conventional servo. It changes during launch to cut control movements to a safe value during the boost phase with altitude to compensate for the variation in atmospheric density.

The missile's electrical power supply is a high frequency alternator regulated to within one per cent in voltage and frequency. Its fine control makes it possible to use the output frequency as a time base that increases *k* progressively after the fins are unlocked at launching. In this way sudden control movements are prevented that would set up oscillations lasting throughout the missile's flight.

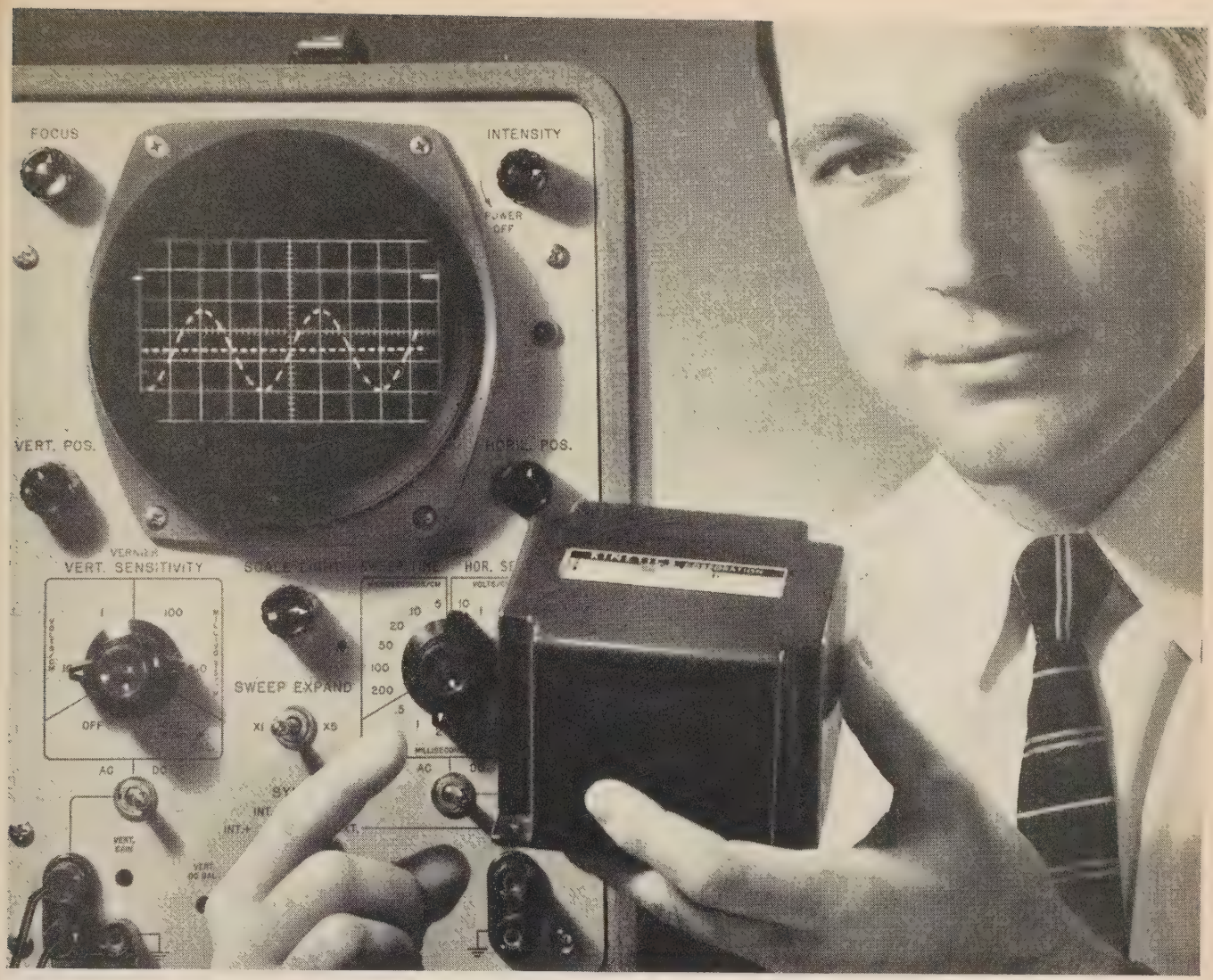
The Firestreak is launched on a pursuit course. Errors developing in flight are removed by a conventional proportional control system. Precession torques applied to the head gyro are proportional to the space rates of spin of the sight line. The resulting currents in the gimbal torque motors therefore give direct measurements of spin rate resolved into the torque motor planes.

The missile is made to turn in each of the two wing planes at rates proportional to the precession currents. The control system produces accelerations on the missile that are proportional to the rate of spin of the line joining missile and target.

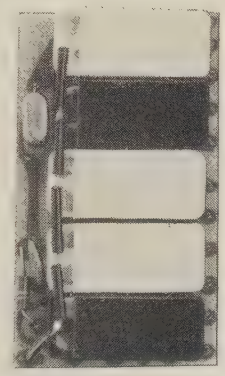
The rate of turn of the flight path is measured by accelerometers mounted in the pitch and yaw axes. A rate gyro in each plane stabilizes the high-gain accelerometer feedback. Filtering is used to decouple the response of the control system from the body vibration mode.

As Firestreak is a boost-and-glide missile, its speed varies considerably, and *k* is not constant, but increases as the speed drops. Though nothing was done to counteract this effect, the system has proved satisfactory, says de Havilland.

The control system also uses a roll-rate gyro to keep the roll rate down to a value that can be handled by the homing-head gimbal system. No position roll stabilization is needed.—End




# Kinetics electronic commutator offers greater accuracy and over 10,000 hrs. life



The Kinetics electronic commutator features modular construction, achieving maximum space utilization and easy application to various configurations.

As shown by the pattern on the scope, the new electronic commutator now available from Kinetics Corporation offers a high degree of commutation fidelity. Note the extremely short rise and fall times with no apparent deterioration of signal. Faithful reproduction such as this will continue through a forecast life of 10,000 hours or more. This commutator is recommended for all aircraft and missile multiplex telemetering systems where accuracy and long life are required.

There are no built-in amplifiers to affect the signal in the straight-forward Kinetics design. This is a solid state unit—semi-conductor components are used throughout. Operating temperature limits are from *−60°C.* to *125°C.* Load resistance of the Kinetics design ranges from 5000 ohms to 2.5 megohms.

This commutator offers excellent low level capability, down in the low millivolt range. Contact resistance is low, from 5 to 10 ohms. Leakage currents are less than .005 microamperes at 5-volt signal levels. Extremely compact construction has been achieved, averaging only .4 to .5 cubic inches per channel, decreasing as channels are added. Power consumption is low. Sampling rates up to 50,000 samples per second are possible.

Write for more information on this electronic commutator. Kinetics Corp., Dept. K-24, 410 South Cedros Avenue, Solana Beach, Calif. SKyline 5-1181.

KINETICS
CORPORATION

ELECTRONICS • ELECTROMECHANICS

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# EXCLUSIVE NEW WESTINGHOUSE HIGH FREQUENCY BUS DUCT BOOSTS POWER SAVINGS... CHOPS VOLTAGE LOSSES

Here's the economical, efficient way to put high frequency exactly where you want it with rock-bottom power loss. The completely new Westinghouse High Frequency Bus Duct is designed for all a-c power distribution systems, particularly those rated 400 to 20,000 cps.

Westinghouse High Frequency Duct distributes power over long runs more efficiently at 400 cycles than most systems do at 60 cycles . . . means that a centrally located high frequency generator can serve an entire plant with a uniform voltage. Gone are the expense, mess and big voltage drops of multi-run cable and conduit schemes...gone is the need for individual, at-the-site power supplies. The all-new duct is designed for 600 volts but can operate at higher voltages for special applications.

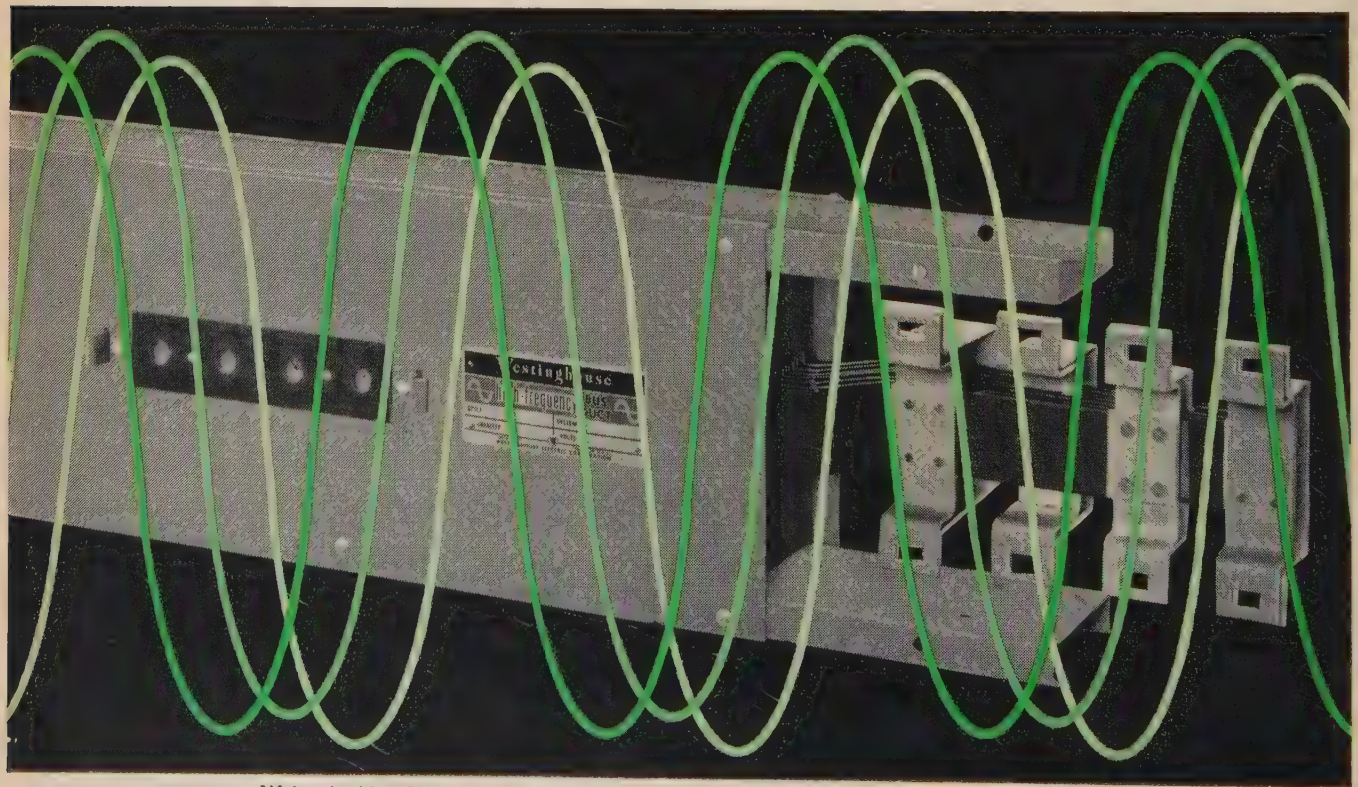
And Westinghouse High Frequency Duct retains all traditional bus duct advantages. Small size . . . light weight . . . power taps every 30 inches over entire duct length . . . location flexibility . . easy installation.

High Frequency Bus Duct is available now . . . and only from Westinghouse. Call your Westinghouse salesman for more details . . . or write Standard Control Division, Westinghouse Electric Corporation, Beaver, Pa.

J-30316

YOU CAN BE SURE...IF IT'S Westinghouse

TUNE IN WESTINGHOUSE-CBS TV-RADIO COVERAGE, PRESIDENTIAL CONVENTIONS, JULY 10-29



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## How to specify and apply

# pressure and gas-density switches

**Pressure and gas-density switches may be the answer design engineers are looking for to solve problems of leakage, electric arc-over, and heat dissipation in electromechanical equipment. They can make all the difference in meeting high altitude and reliability requirements.**

**by Beatrice A. Hicks,** President,
Newark Controls Co.*

WHAT would you give for a device that signals and actuates counter-measures when the density of your electric insulating gas approaches the danger point for electric arc-over? A subminiature gas-density switch can do just that. Gas density and absolue-air-pressure switches that both monitor and control generally can be used to safeguard against leakage, arc-over, and heat dissipation (*Table I*).

Pressure switches fall into two basic groups: *absolute* and *gage*. Absolute-pressure switches monitor gases (or liquids) to detect variations from an absolute pressure regardless of temperature. Gage, or differential-

*more on next page*

*Newark Controls Co., Bloomfield, N.J.

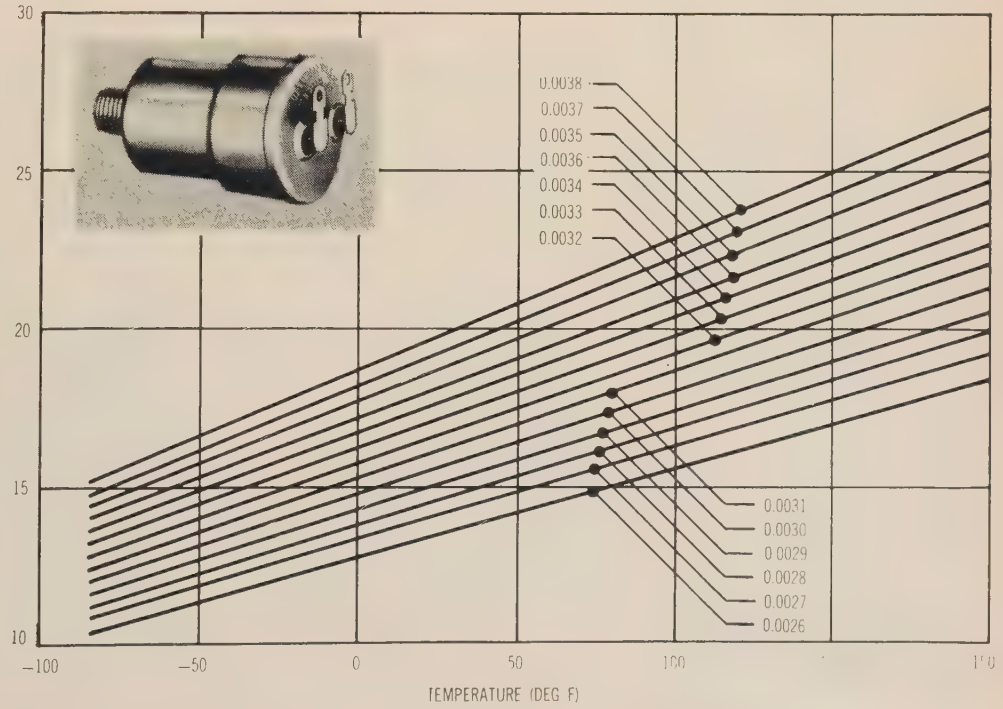
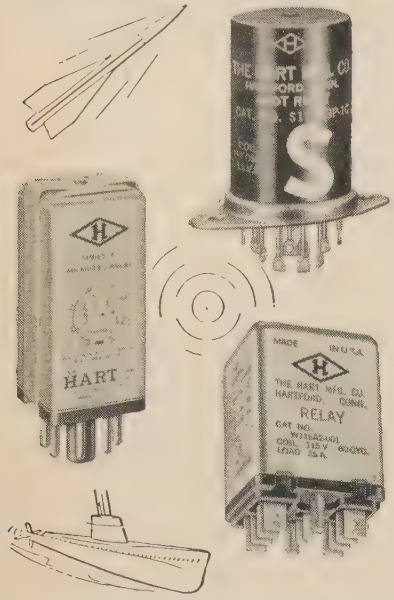



**FIGURE 1:** SN-88 gas-density switch, produced by Newark Controls, signals when the density of an electric insulating gas nears the danger point for arc-over. Graph shows the actuation pressures from —85 to 200 deg F for various SN-88 models.

# Heart of the Control System




# 'DIAMOND H' Relays

"Diamond H" relays have a record of high reliability proved in critical applications ranging from missiles to nuclear submarines. That's why increasing numbers of engineers are specifying "Diamond H" relays in the heart of their control systems.

Hart makes these basic types of relays:

- **Miniature, hermetically-sealed aircraft-missile relays, (Series R and Series S).**
- **High-speed sensitive polarized relays (Series P).**
- **General purpose AC/DC relays (Series W)**

Technical literature outlining the wide range of characteristics available in each type relay is yours for the asking. You'll find "Diamond H" engineers skilled in optimizing the basic designs to meet your specific requirements.

Tell us your needs . . . by phone, wire or letter.

THE HART MANUFACTURING COMPANY

212 Bartholomew Ave., Hartford 1, Conn.

Phone JAckson 5-3491

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**Table I: Application Criteria**

| Application | Type of Switch |
|---|---|
| Detecting critical gas or liquid pressures for protection against stresses and strains due to outside vs inside pressures. | Gage pressure switch (reacts to system pressure as related to ambient pressure) |
| Detecting critical gas densities at relatively constant temperature of operation | absolute-gas-pressure switch or gas-density switch |
| Detecting leakage of gas from sealed container subject range of temperatures | gas-density switch (molecules per cubic foot but not pressure will remain constant with temperature) |
| Detecting critical density of gas for arc-over or heat transfer protection when temperature varies | gas-density switch (gas density for arc-over voltage and heat-transfer characteristics will remain constant over the temperature range, but the gas pressure will not) |
| Detecting critical density of gas or adequate quantity delivery from gas pipe line | gas-density switch (amount of gas delivered depends on gas density as well as speed) |
| Detecting critical gas densities in chemical processes | special gas-density switch for use with specific vapor pressures (detects molecules (or lb-mols/cu ft) of gas irrespective of pressures exerted by liquid vapor |
| Detecting super-saturation or sub-saturation of vapors at constant gas density | special vapor-density switch for use with specific gas and vapor pressures. |

**Table II: Gas Density Switches**

| Parameter | What To Specify |
|---|---|
| Actuating points | Actuating pressures and tolerances at maximum and minimum temperatures on increasing and decreasing gas density |
| Normal operating pressure range | psia |
| Proof pressure | psia |
| Burst pressure | psia |
| Liquids and vapors | specify whether any liquids or vapor pressures will be present in the gases being monitored and whether the vapors will be saturated |

pressure switches, monitor liquids or gases to detect pressure variations in the medium relative to a reference pressure. For instance, a switch actuating at two psig at standard sea level operates at 16.7 (14.7 + 2) psia. At an altitude at which the ambient pressure is 10.1 psia, this switch will actuate at 12.1 (10.1 + 2) psia.

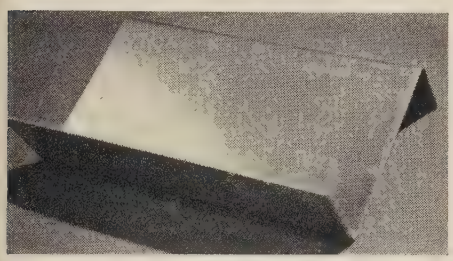
Gage-pressure switches are used

*more on page 186*

DOW | *Now in magnesium and aluminum*

# FOUR MAGNESIUM DEVELOPMENTS ANSWER DESIGNERS' PROBLEMS

**New Dow developments in magnesium provide solutions to critical problems for aircraft, missile and electronics designers. Among them are: a special bend sheet; new close sheet tolerances; precision extrusions; elevated temperature alloys.**



Heated dies are not necessary with Special Bend sheet.

**NEW SPECIAL BEND SHEET** bends easily on standard bending equipment at room temperature. This AZ31B-O Special Bend sheet can be cold-bent without cracking through an angle of 90 degrees around a mandrel radius equal to the bend factor times the nominal sheet thickness . . . bend factor for .040″ to .100″ sheet thickness is 2.0! And tensile yield strength meets the requirements of Federal Specification QQ-M-44.

**NEW CLOSE SHEET TOLERANCES** can now be obtained on standard gauges when required. For example, on .090″ gauge, 48-inch-wide sheet, tolerances can now be held as close as plus or minus .002″. Standard tolerances run plus or minus .004″. These closer tolerances help to cut down on weight penalty, so important in missile and aircraft design.

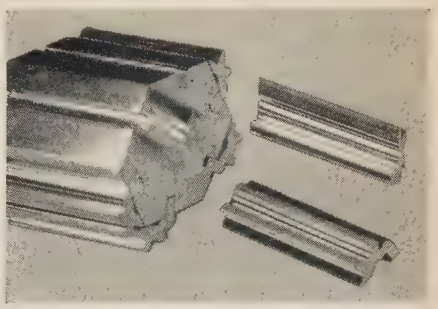
**PRECISION MAGNESIUM EXTRUSIONS** from Dow give you exact-tolerance parts without costly multiple machining operations. Sharp V's, deep notches, thin slots, accurate serrations . . . all can be economically produced in Dow's Madison, Illinois, extrusion plant.

**LARGE EXTRUSIONS.** A huge 13,200-ton press easily handles large sections, stepped extrusions, combined extrusion forgings and single unit extrusions to replace fabrications. This giant can handle sections of up to a 30-inch circumscribed circle!

**ELEVATED TEMPERATURE ALLOYS** are available from Dow for extruded and rolled products. These alloys have excellent static and creep properties, some up to or above 700°F. Because of magnesium's high specific heat, it's an excellent heat sink for instruments and components!

Compared pound for pound with other metals, magnesium permits the use of heavier-gauge, more rigid sections for extra structural strength . . . and substantial weight savings!

Magnesium gives greater rigidity for equal weight than other metals.



Dow precision-extrudes magnesium in almost any cross-sectional shape.

For more information on these products, and on Dow's fabrication facilities for magnesium and aluminum, contact the nearest Dow sales office, or write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Department 1002EW-6.

DOW **THE DOW METAL PRODUCTS COMPANY**

*Division of The Dow Chemical Company*

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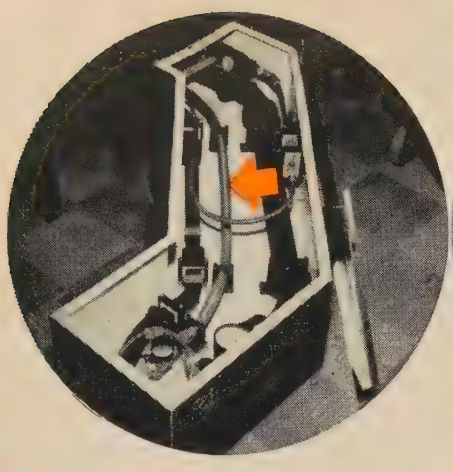
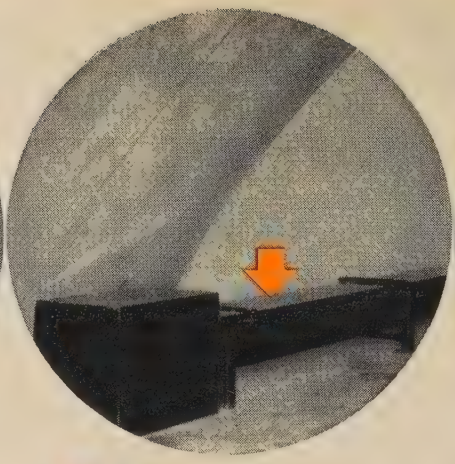


**1.** Within the control blockhouse, 7/8" 50 ohm Styroflex® cable starts its run to the Titan launch Complex 16 at Cape Canaveral . . .



**2.** Following along the domed wall of the concrete blockhouse inside a protective case . . .

**3.** To the conduit that carries the high frequency cable through the massive concrete wall.

# Styroflex® Coaxial Cable

## *helps put the USAF Titan ICBM into space*

The selection of Styroflex® air dielectric cable for use in the missile field was based on its superior electrical properties, uniformity, rugged physical qualities, long lengths that can be pulled up a tower without splicing and the elimination of radiation always present in braided coaxial cables. ■ Already proven in scores of applications, including broadcast, radar, missile tracking and tropospheric systems, Styroflex® cable has a long record of successes since its introduction in Europe in 1937. ■ Next time you have requirements for a high frequency cable with low attenuation and an extremely low inherent noise level, check the qualifications of Styroflex®. Just write Phelps Dodge.

**PHELPS DODGE COPPER PRODUCTS**
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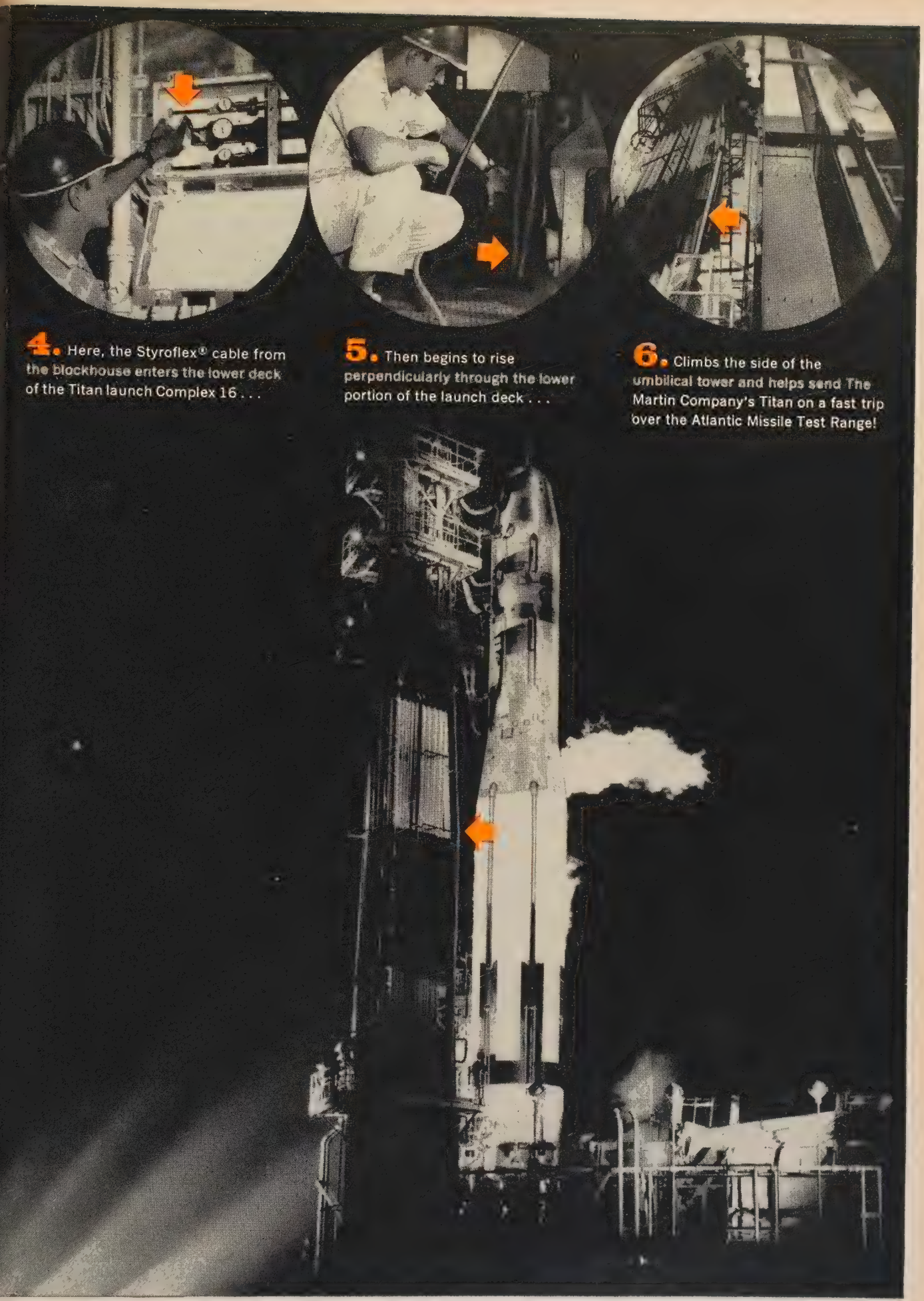

**4.** Here, the Styroflex® cable from the blockhouse enters the lower deck of the Titan launch Complex 16 . . .

**5.** Then begins to rise perpendicularly through the lower portion of the launch deck . . .

**6.** Climbs the side of the umbilical tower and helps send The Martin Company's Titan on a fast trip over the Atlantic Missile Test Range!

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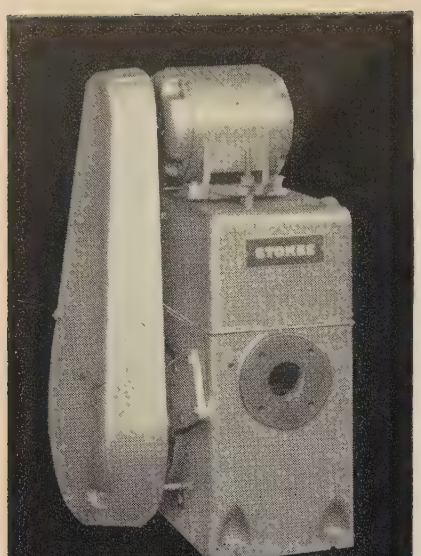
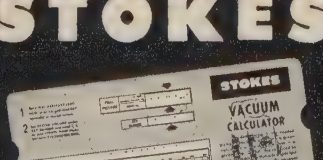



*a vacuum pump as compact as a . . .*

Yes, designed for compactness . . . and with no costly extras to buy. Saves up to 50% of your valuable floor space. But these are just a few of the revolutionary features of the new Stokes Series H Microvac pump.

Find out why Stokes offers you *more pumping performance per dollar*. Just write: Vacuum Equipment Division, F. J. STOKES CORPORATION, 5500 TABOR RD., PHILA. 20, PA.

**STOKES**

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for your free
Vacuum Slide Calculator!

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## Table III: Common Switch Requirements

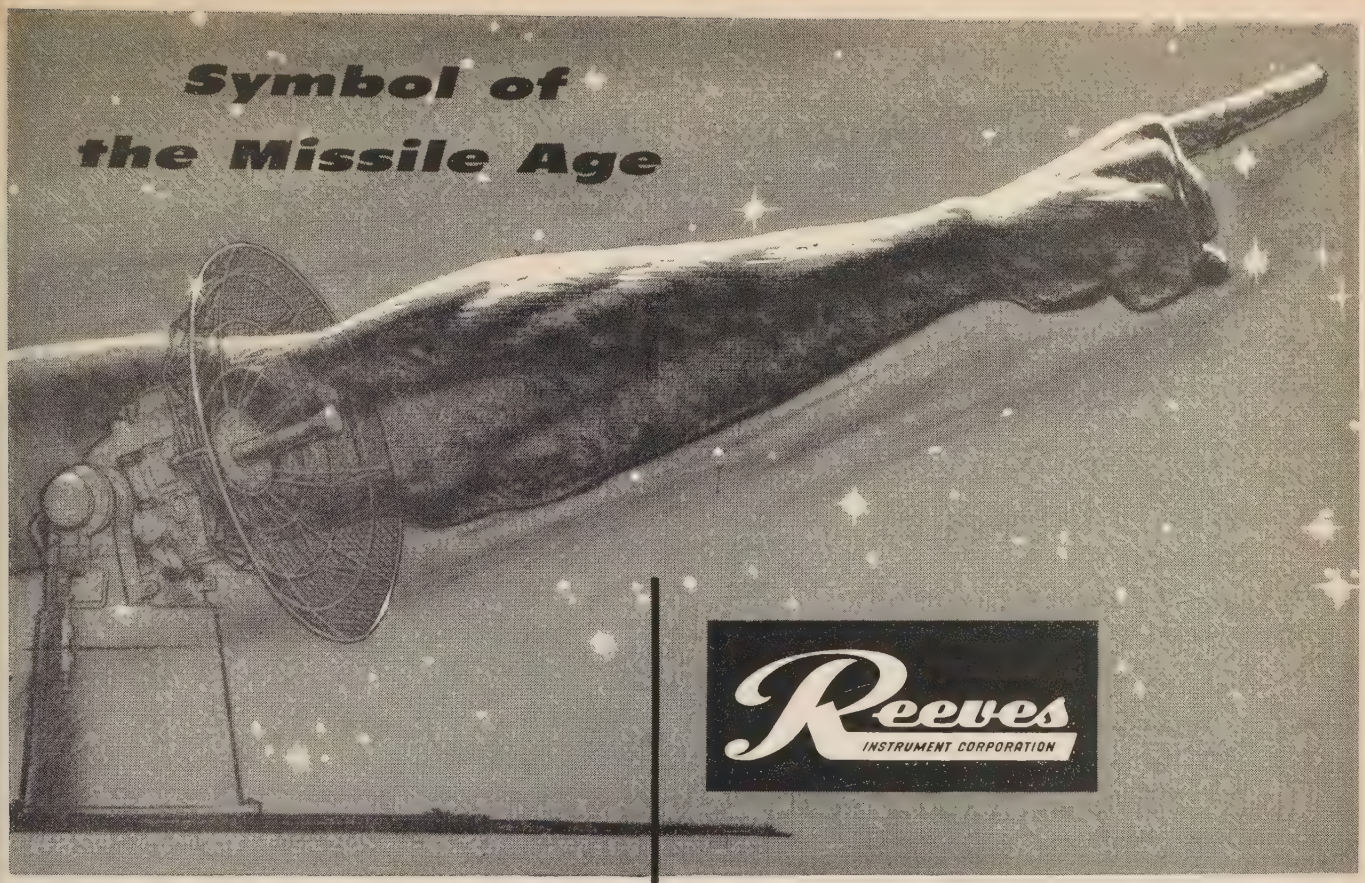
| Parameters | What To Specify |
|---|---|
| **General** | |
| Form factor | any unique requirements |
| Dimensional limits | maximum overall size |
| Weight | maximum |
| Electric connections | any unique requirements |
| Gas or liquid-medium connection | any unique requirements |
| **Operating Environments** | |
| Gases or liquids in medium | chemical formula or popular name |
| Temperature range | minimum and maximum; length of time unit may be subject to each |
| Rate of change of temperature | maximum rate at which ambient temperature will change |
| Humidity range | minimum and maximum relative humidity and length of time unit may be subject to each |
| Vibration | frequency range, double amplitude or g, and axis of applied vibration, if contacts must not chatter, specify that during testing switch shall be subjected to pressure half-way between opening and closing pressures |
| Shock | g, wave shape, period of wave, axis and direction of applied shock under test |
| Acceleration | g, duration, axis and direction of applied force under test |
| Response time | maximum allowable response time measured from the time the pressure on the switch reaches the actuating point |
| Operating life | number of cycles |
| **Storage and Transportation Environments** | |
| Temperature range | minimum and maximum |
| Humidity range | minimum and maximum |
| Vibration | frequency range, g or double amplitude, axis of applied vibration under test |
| Shock | g, wave shape, period of wave, axis and direction of applied shock under test |
| **Electric Characteristics** | |
| Contact arrangement | SPST open (or close) on decreasing pressure, or SPST open (or close) on increasing pressure, or SPDT; specify whether actuating point on increasing or decreasing pressure is the one on which maximum accuracy should be held |
| Voltage and frequency | volts ac or dc, cycles per second |
| Current | amperes, resistive loading |
| Dielectric requirements | minimum allowable voltage without insulation breakdown* |
| Insulation resistance | minimum allowable resistance at a specified voltage |

* In many pressure and gas-density switches, the materials of construction will not break down at substantial voltages, However, the air or gas between the electrical contacts will arc over. This arc-over occurs more readily at lower gas densities; it does not occur at all below 275 V. If arc-over between electric contacts is to be prevented at voltages above 275 V, the maximum voltage must be specified. Pressure switches should be tested at maximum voltage while the pressure and temperature are at the minimum operating conditions. Gas-density switches should be tested at the minimum operating conditions regardless of temperature.

to trigger equipment functions or signaling devices in response to certain liquid or air gage pressures. Absolute-air-pressure switches are used for equipment operation and control in response to certain pressure limits or altitudes, for pressure alarm and safety signaling, and for monitoring air-pressurized airborne electronics. We developed our RC-55 absolute-air-pressure switch, for instance, to operate on-off in a ground-based radar within one pound of a specified setting between 15 and 85 psia and over a wide range of temperatures. Moreover, this switch must be independent of barometric pressure and altitude.

*Figure 2* shows a typical absolute pressure switch, which was designed

more on page 190



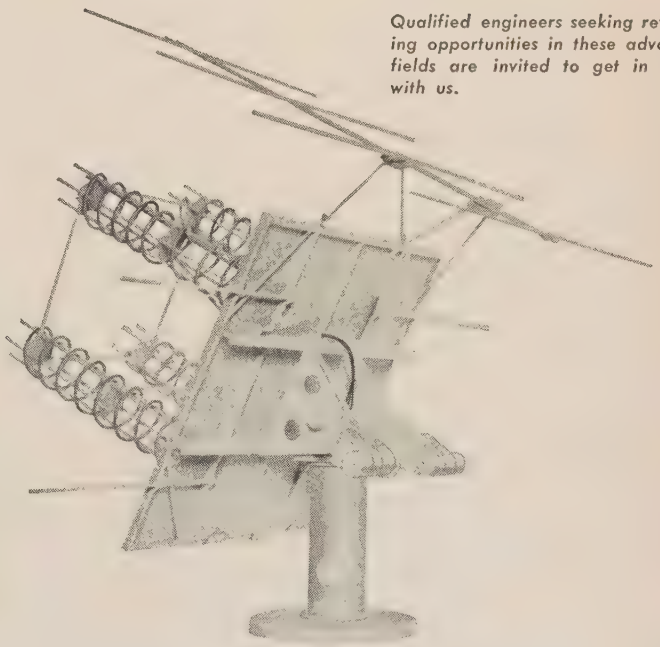

# antenna systems capability

The directional antenna and its mount have become symbols of the missile age and its advancing technology. Representing a challenging complex of mechanical and electronic problems, they demand the utmost in ingenuity and precision for their solution.

Reeves has over ten years of diversified experience in the coordinated design and development of two and three axis antenna mounts and their related servo, radar and computer instrumentation. Currently actively engaged in the DISCOVERER and PROJECT MERCURY PROGRAMS, Reeves has produced antenna systems for the TERRIER and MATADOR programs, as well as a wide range of mounts for other missile tracking and guidance applications.

If your projects involve development of advanced antenna pedestal equipment and systems for search, tracking, guidance or control, it will be worth your while to contact Reeves.

*Qualified engineers seeking rewarding opportunities in these advanced fields are invited to get in touch with us.*



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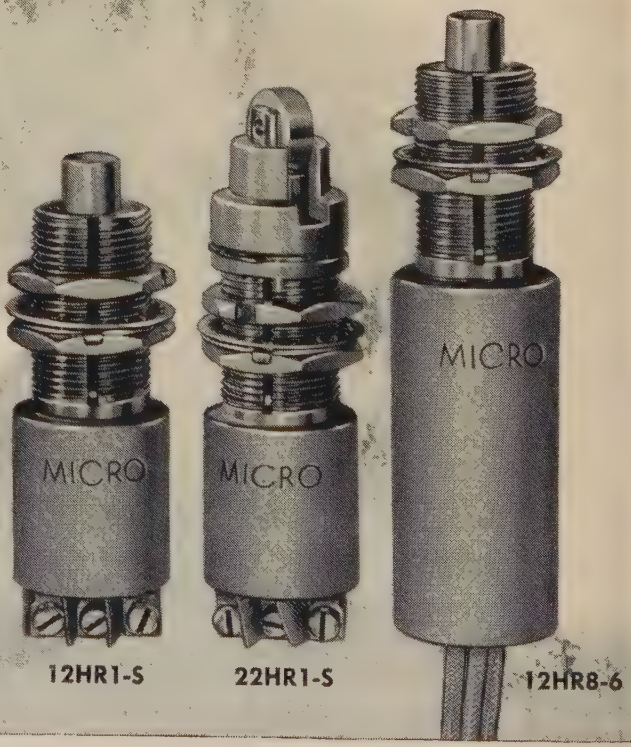
# Sealed and Shock-Resistant ...precision

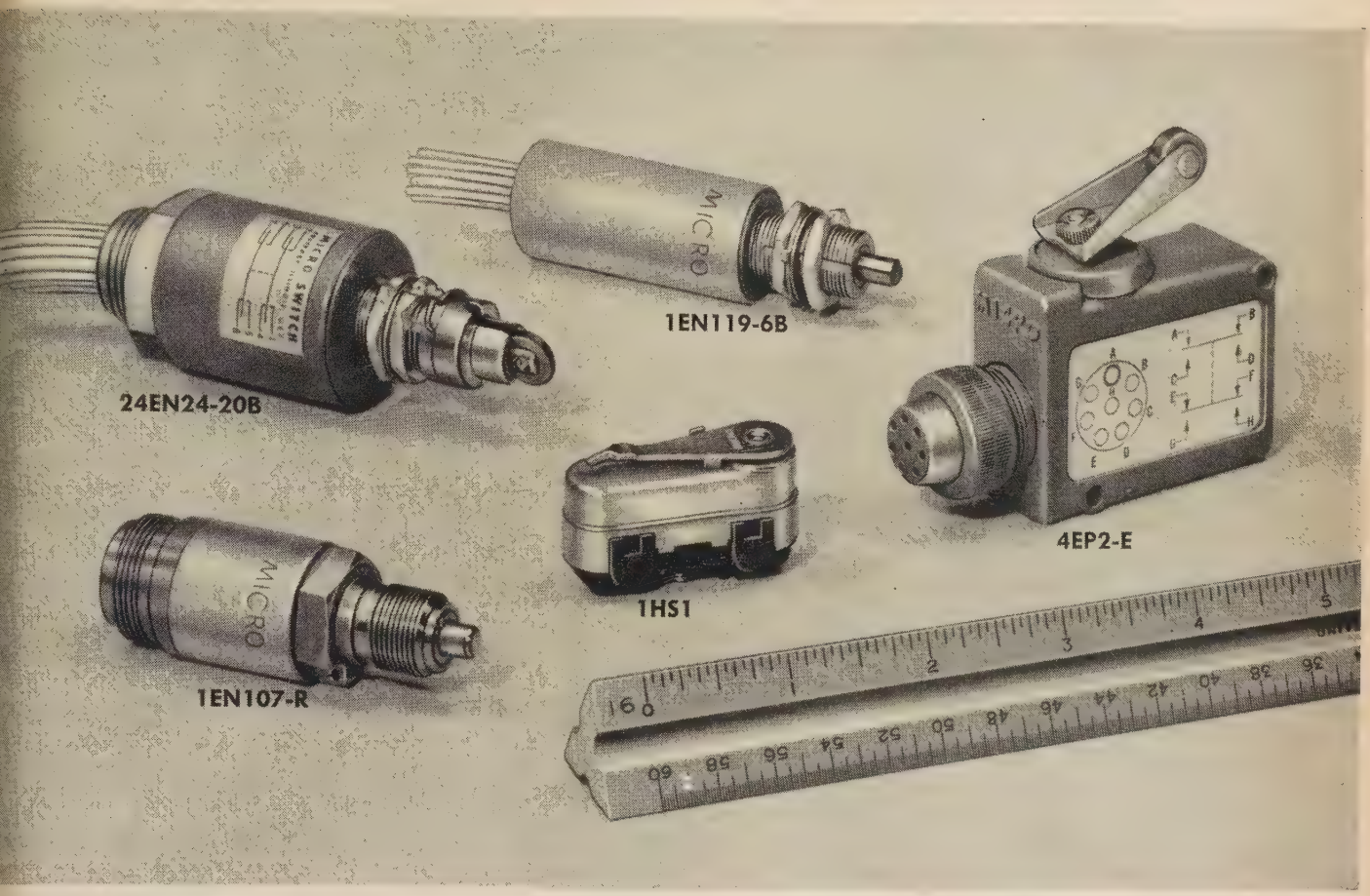
## Hermetically Sealed "HR" Switches

Explosive shock or high temperatures from missile exhausts present no problem to MICRO SWITCH "HR" switches. They are hermetically sealed to maintain constant operating characteristics regardless of changes in atmospheric or environmental conditions. "HR" switches operate dependably in a temperature range of −65° to +600°F. All exposed parts are corrosion resistant. To qualify as a true hermetically sealed switch, the chamber containing the switching element is evacuated and filled with inert gas; the conductor sealing is glass-to-metal and metal-to-metal, and the contained switching unit is actuated through a sealed metal diaphragm. An ice scraper ring on the actuator shaft removes ice or mud which might cause jamming or binding. Write for Catalog 77 which describes "HR" and other MICRO SWITCH enclosed switches for airborne equipment.

**12HR1-S** and **22HR1-S** — Both contain two single-pole double-throw snap-action switching units. 5 amp. (resistive), 28 vdc.

**12HR8-6**—Has high-temperature lead-wire extending from internally threaded conduit hub. 5 amp. (resistive), 28 vdc.






# switches for missile launchers

The most complete test laboratory in the precision switch industry makes it possible for MICRO SWITCH to test switches under severe conditions of shock, vibration, temperature or altitude. This has made possible a complete line for missile, aircraft, rocket, launcher, marine and ordnance applications. Here are just a few of the switches specially designed for missile launching:

**1EN107-R** Meets BUORD requirements, can withstand 1,000 pounds of sea water pressure per square inch. Has two high-shock basic switches. Write for Data Sheet 176.

**4EP2-E** Sturdy housing, exceeds shock and vibration resistance tests MIL-S-6743 and MIL-S-6744. Also meets immersion tests for MIL-E-5272A. Conduit hub houses sealed solder terminals and elastomer seal gland. Write for Catalog 77.

**1HS1** Single-pole double-throw contact arrangement, conductors sealed in glass. Metal housing is evacuated and filled with dry inert gas under pressure, a true hermetic seal. Write for Catalog 78.

**1EN119-6B** and **24EN24-20B** Both are used on missile test stands. Environment-proof seals with ice scraper rings on actuator shafts to remove ice or mud which might cause jamming or binding. Write for Data Sheet 176.

A nearby MICRO SWITCH branch office puts capable switch experience close to you to save time. See the Yellow Pages for the telephone number.

MICRO SWITCH . . . FREEPORT, ILLINOIS
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PIONEERING THE FUTURE

**Honeywell**
**MICRO SWITCH Precision Switches**

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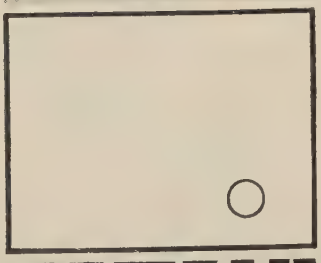
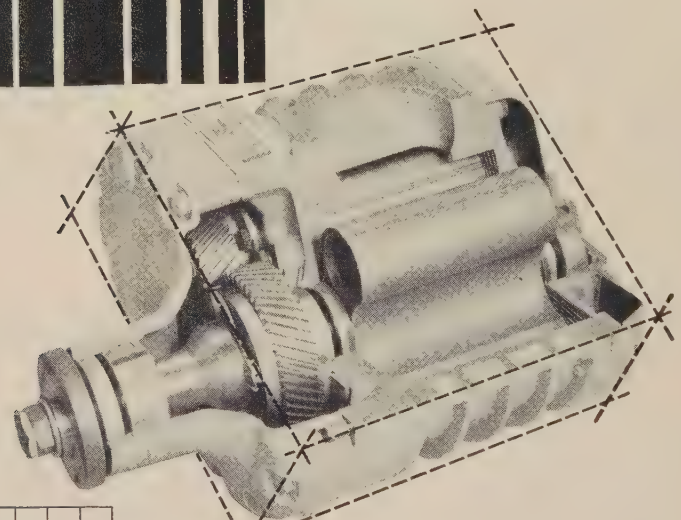
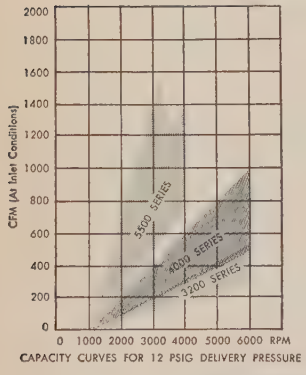
SMALLEST CUBE DIMENSIONS



LIGHTEST WEIGHT

WIDEST PRESSURE RANGE






**WITH M-D 3-LOBE BLOWERS**

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 11 production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.

*For full information write*

**M-D BLOWERS, INC.,** RACINE, WISCONSIN
**A Subsidiary of Miehle-Goss-Dexter, Inc.**

**Write in No. 180 on Reader Service Card at start of Product Preview Section**




to operate from —85 to 400 deg F. It weighs less than 1.8 oz and is about two inches long. Maximum shift in pressure actuating points over a broad vibration spectrum is 0.3 psi.

### The actuating characteristics vary with temperature

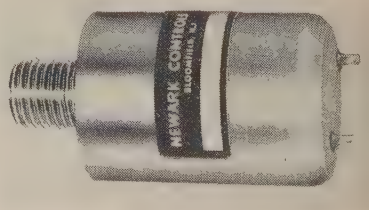
Gas-density switches which are temperature-dependent and actuate at various pressure-temperature combinations, detect changes in gas densities. Since the pressure of the gas being monitored varies with temperature, the actuating characteristics vary accordingly. If the gas density is expressed in pound-mols per cubic foot, all gases of the same molecular density that are governed by the perfect-gas law will have the same pressure-temperature variation. Therefore, you use this type of switch when you want to detect a loss or change in the pounds per cubic foot of the gas rather than a change in pressure. Of course, to convert gas densities from pound per cubic foot to pound-mols per cubic foot, you divide by the molecular weight of the gas.

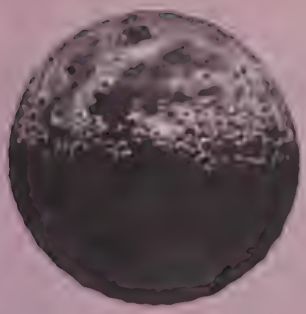
We are producing three major types of gas density switches:

- The RM-73 is used on the Boeing 707. Located in a sealed electronic assembly that houses the rear antenna coupler, it prevents electric arc-over in the rarefied upper atmospheres. It monitors the artificial atmosphere (nitrogen) used as the insulating agent in the sealed system by sensing the molecular density of the gas. If a leak develops or the gas density approaches the arc-over conditions, the switch actuates a signal that operates an alarm in the cockpit.
- The SN-88 is used to control the artificial atmospheres in a sealed electronic weapons system during storage. Designed to keep gas at a specified density level, it has an

*more on page 192*

**FIGURE 2:** Absolute-pressure switch monitors a constant pressure from —85 to 400 deg F.





# MEASURING THE PULSE OF A MAN-MADE WORLD

Project Mercury Astronaut traveling in ... requires a capsule world which presents a minimum of random vibrations in structure or equipment. Endevco Corporation, under contract to McDonnell Aircraft, capsule prime contractor for National Aeronautics and Space Administration program, provides the highly sensitive and accurate instruments required to measure undesirable vibrations in the capsule. For Technical Information about Endevco Transducers and Amplifiers write direct to: Department P'M, **Endevco Corporation,** 161 East California Boulevard, Pasadena, California, or Phone: SYcamore 5-0271.

Σ

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STAINLESS STEEL TUBING

Pressures demanded by missile, rocket and supersonic aircraft hydraulic and pneumatic systems of current military specifications are emphatically resisted by dependable PATCO stainless steel tubing.

PATCO Stainless Steel Tubing, as well as PATCO Carbon and Alloy Steel Tubing, is produced in lengths up to 58 feet. PATCO also produces cold drawn bars—rounds, squares, hexagons—in carbon and alloy steels. Your orders for stainless, carbon or alloy steel tubing, as well as cold drawn bars, are promptly shipped when sent to either Pacific Tube or your local Steel Service Center.

Next time, specify PATCO tubing and bars.

patco

PACIFIC TUBE CO.

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WESTERN REPRESENTATIVE FOR SUPERIOR TUBE CO.

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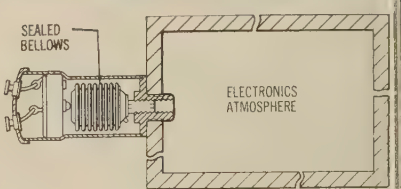



**FIGURE 3:** Non-linear gas density switch. Diagram shows one way of attaching the device to a sealed electronic compartment to monitor and control the artificial environment.

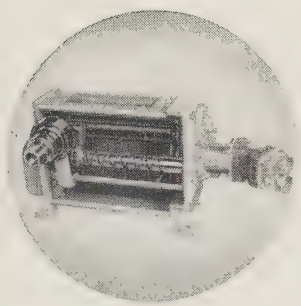
operating range of —85 to 200 deg F (*Fig. 1*). The RM-76 version of this switch extends the temperature range to 400 deg F.

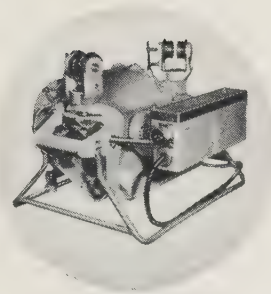
• The SN-98 is a non-linear switch (*Fig. 3*). It operates on a gas-plus-liquid-vapor-pressure principle that involves an hermetically sealed bellows. A reference density (of gas plus vapor) is sealed within the bellows. With the exterior of the bellows exposed to the gas-and-liquid-vapor environment within sealed electronic equipment, the internal pressure of the bellows follows the external pressure. When the monitored pressure falls below the precalibrated pressure of the bellows, the switch signals this drop. Conversely, if the external pressure is greater than the pressure within the bellows, the latter will expand enough to operate an electric snap-action switch.

Monitoring gas densities in the presence of vapors in which the constituent gases and liquids are not mutually soluble has been a most difficult problem. To solve it, a special non-linear gas-density switch had to be developed. Used chiefly as a safety or control device for either cooling or high voltage protection of airborne or ground-based equipment, this switch signals the approach of critical gas-plus-vapor densities regardless of temperature or pressure changes. This device obviously can be applied when fluorochemical refrigerants and fluorocarbon vapors are used as insulating media and cooling agents, respectively, in densely

more on page 196

# Application Engineered HOISTS and WINCHES for Working Whirlybirds





Lift—move—place—That's the job helicopters are doing today.

And the muscles that make it possible are small, powerful, lightweight winches and hoists, that do rescue work, cargo handling—even boom work.

Breeze Corporations make a line of fail-safe airborne winches and hoists. Today's sophisticated designs have matured through years of engineering to the point where a hoist for a flying crane carrying 100 feet of cable can lift a 12,000 pound working load at a rate of 80 feet per minute—yet the whole unit weighs only 750 pounds including the cable. The hoist also has a towing capacity of 30,000 pounds when the helicopter is used to tow boats or other loads.

Breeze winches and hoists are also designed for other airborne systems for any purpose. You'll want a copy of Catalog 99WH which includes design information and specifications of existing equipment.

BREEZE MARK

**BREEZE CORPORATIONS, INC.**

*700 Liberty Avenue, Union, New Jersey • Telephone: MUrdock 6-4000*

*Manufacturers of electrical, electro-mechanical and hydro-mechanical components and systems and fabricated metal products.*

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*At 00h00m01s GMT, June 1, 1960,*
*Martin logged its 557,544,000th mile*
*of space flight*

## ICBM HARD BASE:

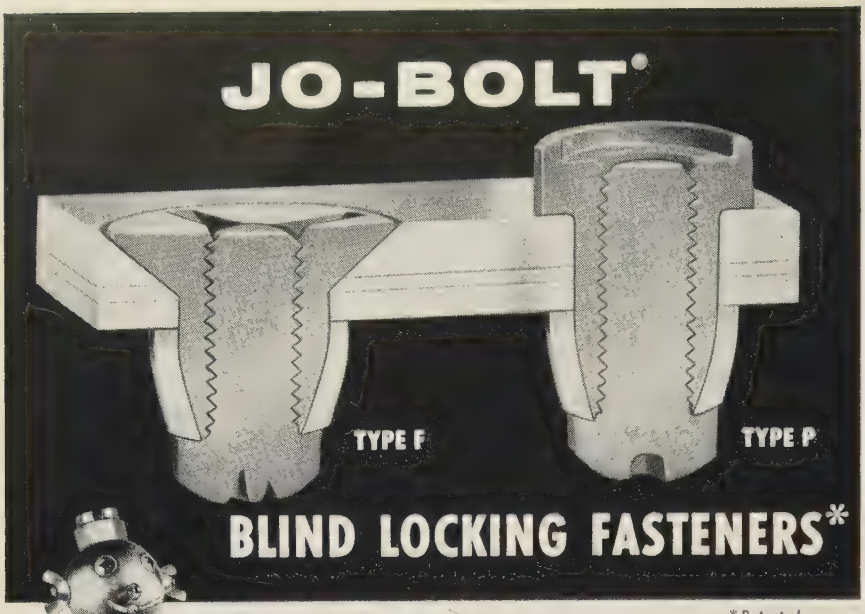
This mammoth excavation, somewhere in the United States, will soon be a "hard base"—an almost invulnerable underground launch site for the Air Force TITAN Intercontinental Ballistic Missile.

It is an important element in the United States Air Force Strategic Air Command's mission—to prevent war.

The job of this TITAN hard base—and the others like it—is to insure that we will have such devastating retaliatory power, even under concentrated nuclear attack, that no enemy will consider war.

Bases such as this cannot be built overnight. It is a credit to the foresight of our military planners that the bases will be operational concurrent with the TITAN ICBMs now in production at Martin-Denver and undergoing advanced tests at Cape Canaveral.

**MARTIN**

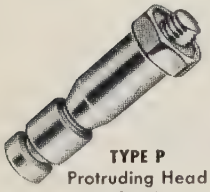



* Patented

## DO IT BETTER · DO IT FASTER in missile/aircraft frame assembly

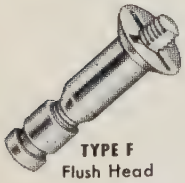
What happens in JO-BOLT Fastener installations can be seen at a glance, in the cross section above. The resulting clamp-up of sheets and structural members is tight and positive, 100% effective.

That's highly important . . . but not even the half of it. First, consider this . . . JO-BOLTS® are high-strength structural fasteners, typically providing: shear strength of 95,000 psi min. in steel types; 85% AN Bolt tensile strength in #10 and ¼" diameters; vibration resistance superior to bolts with lock nuts.



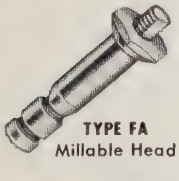
**TYPE P**
Protruding Head
Steel

Second, JO-BOLT Fasteners are lightweight and compact, allow savings in fastener weights averaging 50% or higher, often permit use of narrower and lighter substructures.



**TYPE F**
Flush Head

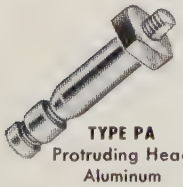
Third, JO-BOLT Fasteners can always be installed by one man from one side of the work . . . eliminating most common access and clearance problems.



**TYPE FA**
Millable Head

Finally, JO-BOLT Fasteners are foolproof and fast, can be popped into holes prepared and aligned for them, and driven to grip inside of seconds, always resulting in high-quality work, uniform and unmarred, regardless of worker skill.

They are so good, in fact, at fastening better and faster that they've been preferred and specified in practically all high-performance aircraft ever since introduction.



**TYPE PA**
Protruding Head
Aluminum

Write for illustrated booklet J 59. It lists specifications for all types, tells about A 286 Hi-Temp and other special JO-BOLT Fasteners.

National Screw & Mfg. Products

**THE NATIONAL SCREW & MFG. COMPANY**
CLEVELAND 4, OHIO
**California Division, Los Angeles 22**

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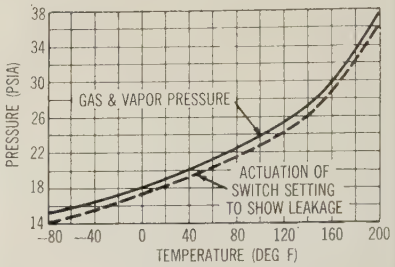


**FIGURE 4:** Pressure vs temperature for a typical SN-98 gas density switch. The monitored environment is made up of 0.00368 lb-mols/cu ft of nitrogen and $C_8F_{16}O$, liquid vapor (developed by Minnesota Mining).

packaged miniature electronic units (*Fig. 4*).

You must be prepared to specify the characteristics you want to the switch manufacturer. (*Tables II-IV.*)

To let him determine the range of normal operating conditions for your device, you have to give the manufacturer the pressure requirements outlined in *Tables II & IV*. You can specify these pressure data in pounds per square inch absolute, gage, or differential (psia, psig, or psid). You may also specify in inches of mercury, but then you'll have to refer to the standard temperature and gravity values of mercury. Pounds per square inch, on the other hand, is an absolute value and requires no such reference.

### Specs must include statement about false transfer

If your device must operate under vibration, shock, and acceleration, you must specify whether the contacts may falsely transfer or not. In case false transfer is not allowed, you must indicate that environmental tests of your equipment should be run at a pressure that falls short of the actuating pressure by a specified tolerance. For instance, if your switch has to close at 10 psia on decreasing pressure but must not close at 10.5 psia under maximum shock, vibration, or acceleration, then tests should be run with the contacts open and the pressure on the switch at 10.5 psia.

These actuating pressures need not coincide with the normal pressure of the gas at the specified temperatures (*Table III*). You can set

**more on page 200**

# WORKING PARTNERS

## RCA 501 — SOUNDCRAFT INSTRUMENTATION TAPES

R-96

Big business depends more and more upon electronic data processing. For many corporations, the heart of their data reduction and storage operation will be the new RCA 501 Computer System. The crucial testing period of this new computer called for the most reliable of instrumentation tapes . . . Soundcraft. And, Soundcraft Tape proved to be the perfect working partner—not only in the testing, but afterward, in continuous working use.

In short, experience has proven that Soundcraft works best on leading computer systems, like the RCA 501. Let precision-made, trouble-free, error-free Soundcraft Instrumentation Tapes go to work for you. *Complete literature on request.*

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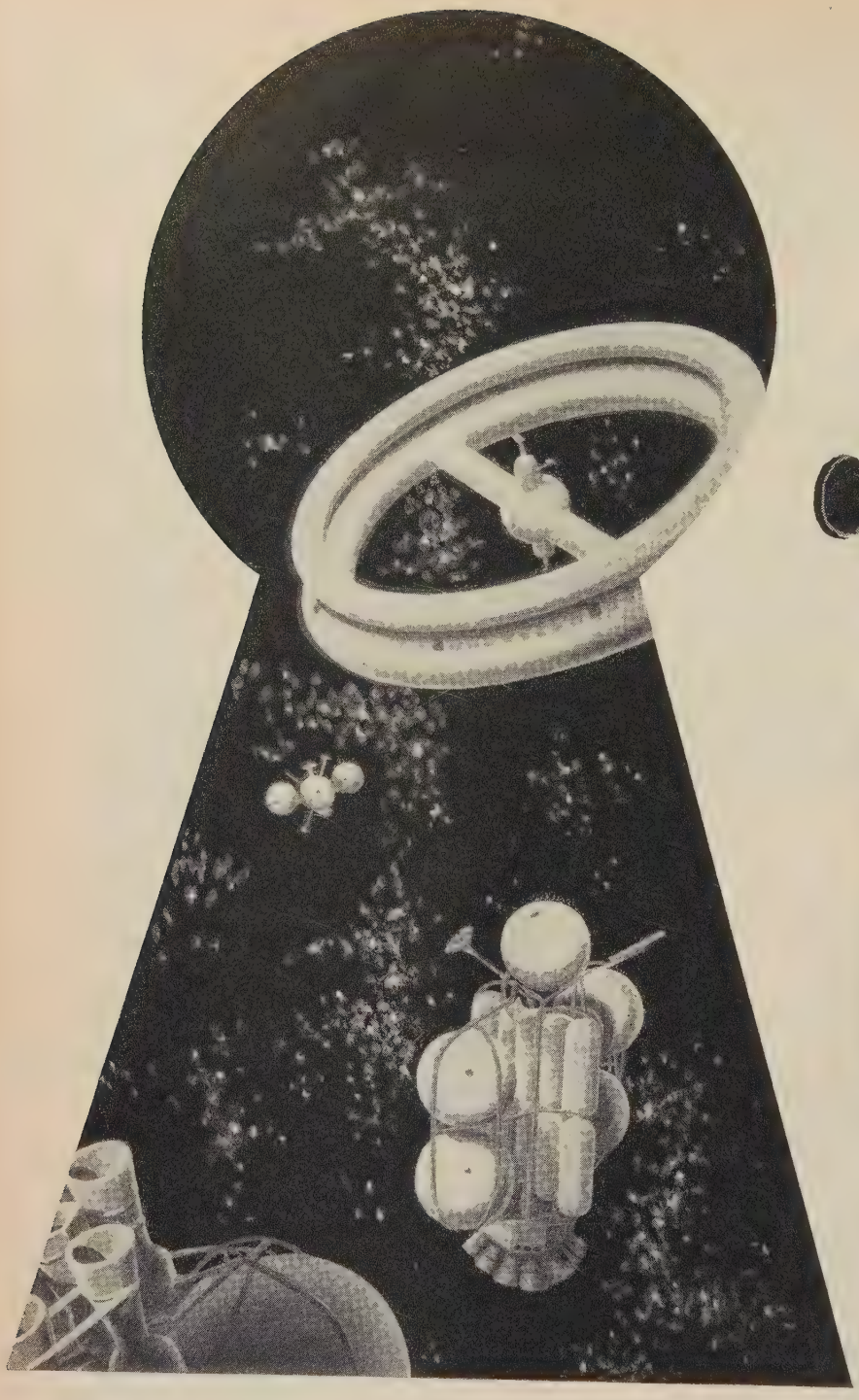
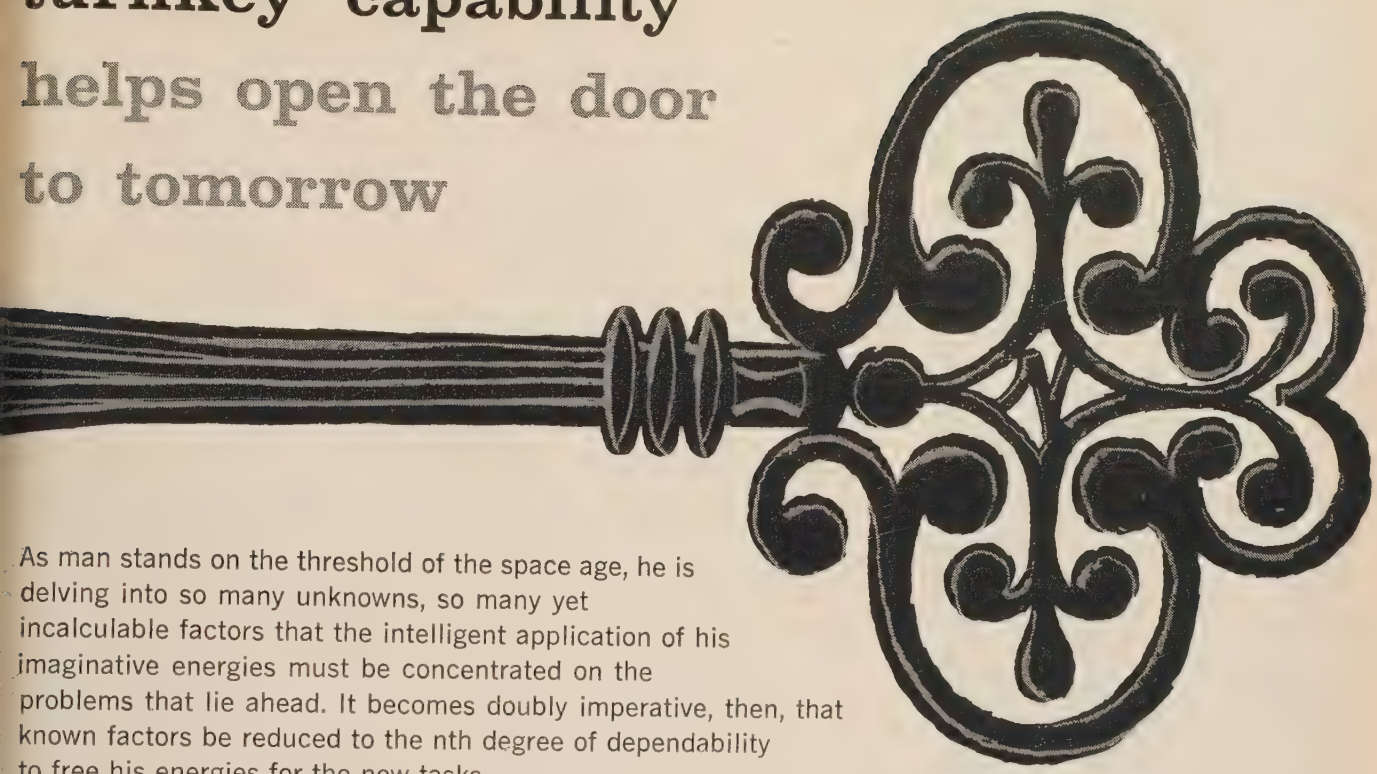


# North Electric's "turnkey" capability helps open the door to tomorrow



As man stands on the threshold of the space age, he is delving into so many unknowns, so many yet incalculable factors that the intelligent application of his imaginative energies must be concentrated on the problems that lie ahead. It becomes doubly imperative, then, that known factors be reduced to the nth degree of dependability to free his energies for the new tasks that lie beyond the known.

North Electric has already been an invaluable partner in the first exploratory steps toward full realization of man's venture into space.

North Electric's experience in the field of ground environmental support control and communications, testing, missile check-out and similar supporting work has developed at North full "turnkey" operational and management capabilities as already applied in control and communications switching centrals for BMEWS and AIRCOM, in fixed and mobile channel control centers for Morocco—Spain—U. K. Tropospheric-Scatter complex and ground communications equipment for the

THOR and JUPITER projects.

From design and development through engineering and manufacture to installation, training and operation, North can bring to you the experience, technical and professional integrity, and system management talents that have made "dependability" and "North" synonymous in these fields.

North's unique capabilities in the fields of control and communications stem from the wealth of experience and genuine talent embodied in an engineering group whose entire professional environment lies in the application of system concepts to problems such as may be facing you right now. To learn how North can help you today, write Dept. SA-1.

*ELECTRONETICS DIVISION*

***NORTH ELECTRIC COMPANY***

*Galion, Ohio*

NORTH

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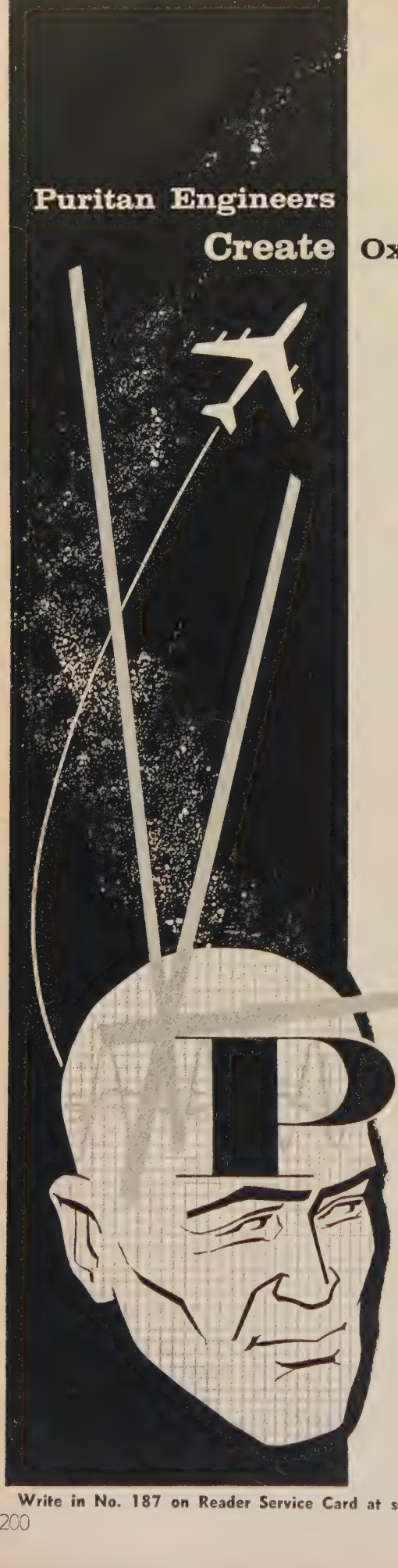
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Create Oxygen Equipment
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As a pioneer in the research, development and manufacturing of oxygen breathing systems in both the medical and aviation fields, Puritan has accumulated unique experience and know-how that precisely bear on the problems you face today. The challenge of your requirements, either for a new installation or improving your present oxygen system, would be welcomed by Puritan's R & D.
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**Table IV: Absolute and Differential Pressure Switch**

| Parameter | What To Specify |
|---|---|
| Actuation pressures | pressure and tolerance at actuation on increasing and on decreasing pressure; specify whether pressures are absolute, gage, or differential |
| Normal operating pressure range | psia, psig, or psid |
| Proof pressure | psia, psig, or psid |
| Burst pressure | psia, psig, or psid |

the switch to actuate above or below the normal pressure of the gas to warn of approaching critical densities.

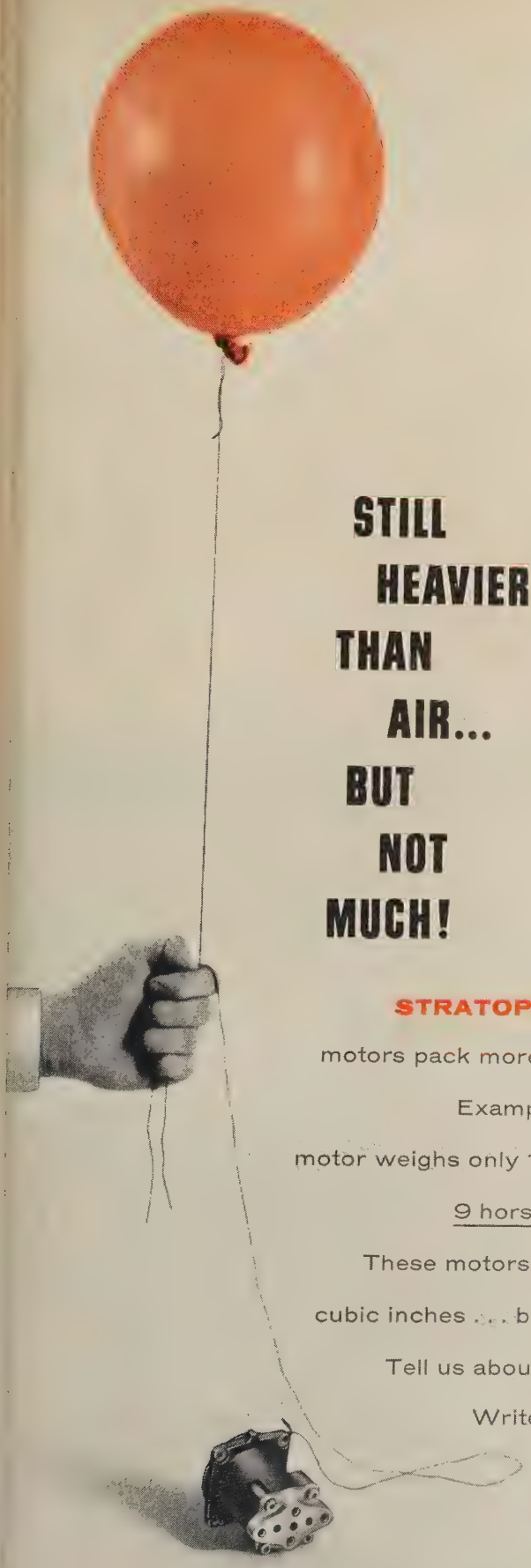
When gases are at constant moderate densities (in lb-mols/cu ft) pressure varies linearly with temperature, and the specified actuating pressures at maximum and minimum temperature fully define the action of the switch. However, when liquids and/or substantial vapor pressures are also present and the gas pressure variation is not linear with temperature, you have to call out what the gases, liquids and vapors are. Switches can be modified to operate along any positive, non-linear pressure-temperature characteristic. Write in No. 6 on Reader-Service Card for more information.—End

## Corrections

A whopper of an error crept into the report on Boeing's new radio isotope altimeter in the Aerospace Electronics Intelligence in the April 1960 issue (*p. 118*). The item stated it as Boeing's claim that the accuracy of the altimeter "depends much more on vehicle speed, altitude, and configuration than does that of conventional pressure altimeters." What Boeing really claimed and the item should have said is that the new altimeter depends much *less* on vehicle speed, altitude, and configuration.

Nine hundred megacycles got lost in "Radio Link to Space," in the March 1960 issue. The last sentence starting on *page 141* read: "At 100 mc, the free-space loss amounts to 254 db." It should have read: "At *1000* mc . . ."

A typographical error occurred in the byline for the Readers' Round Table feature in the May 1960 issue (*p. 350*). The author's name is B. D. *Jarman,* not Jamanr.



# STILL HEAVIER THAN AIR... BUT NOT MUCH!

**STRATOPOWER'S** new light weight axial-piston hydraulic motors pack more power per pound.

Example? STRATOPOWER'S production model .1 cubic inch motor weighs only 1.8 pounds. But you can pour 9 horsepower through it at 16,000 RPM.

These motors are available NOW in sizes from .05 to 4.5 cubic inches . . . built to our specifications or yours.

Tell us about your requirements.

Write to Department S-200 WF.

**WATERTOWN** DIVISION
THE NEW YORK AIR BRAKE COMPANY
STARBUCK AVENUE • WATERTOWN • N. Y.

Qualified engineers in hydraulic and control design are invited to investigate their potential in the STRATOPOWER organization. Please contact Mr. Watkins, Personnel Manager.

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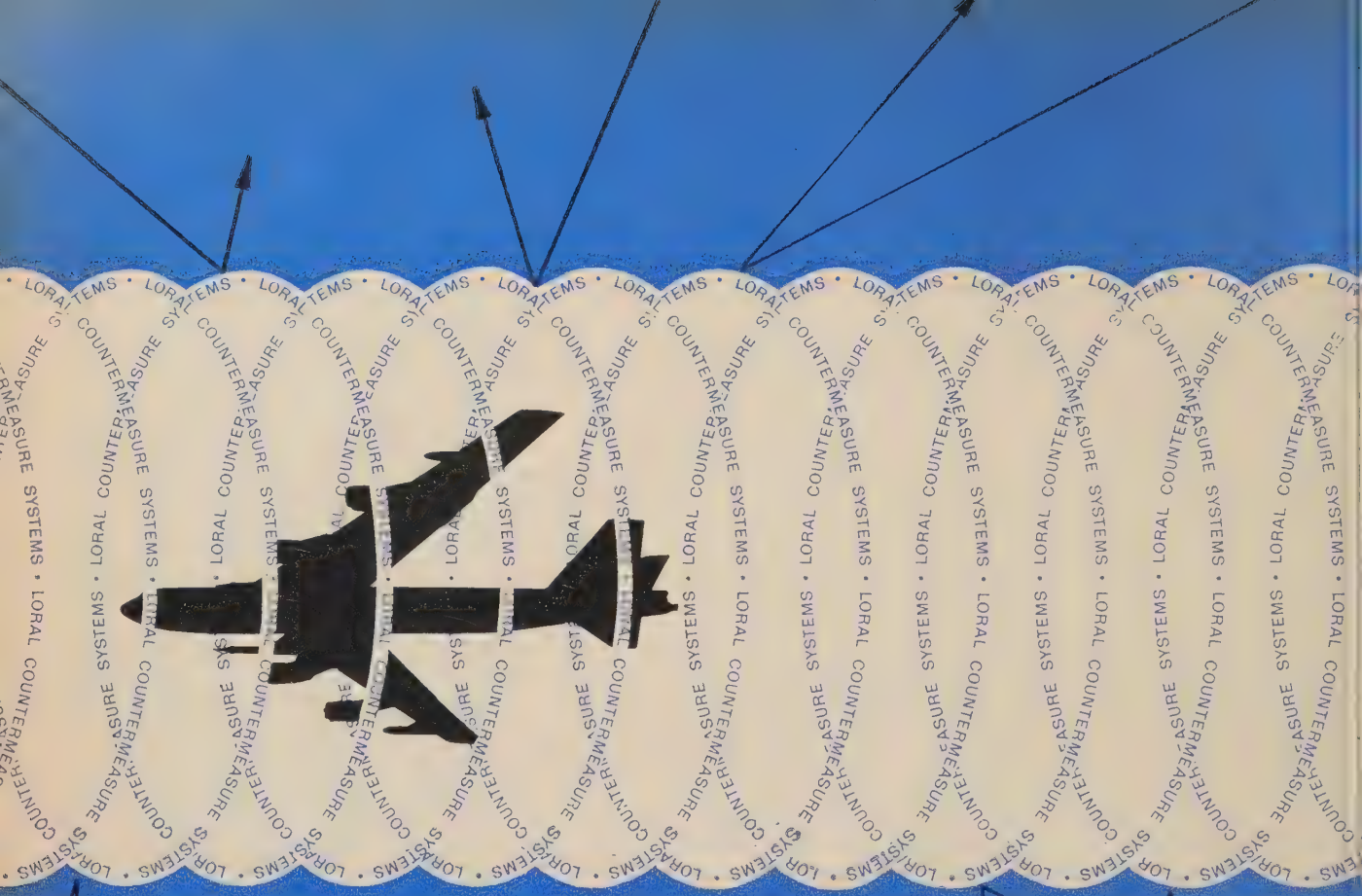



# DEFENDING THE BOMBER:
# LORAL COUNTERMEASURE SYSTEMS

LORAL

## LORAL ELECTRONICS CORPORATION New York 72, N. Y.

Washington, D. C. • Dayton, Ohio • Tustin, Calif. • Designers and producers of electronic aids; also systems for anti-submarine warfare, airborne early warning, navigation, reconnaissance, countermeasures, and passive detection.

**ELECTRONIC** devices for handling flight data are still not generally accepted in England. However, most of the advanced firms have abandoned their attitude of distrust and consider the electronic data handling equipment more reliable than either the missiles they are testing or the British weather. There is some talk of buying U.S. electronic equipment for test programs, since it is well tried and available. Many Britishers, though, consider the use of imported equipment unwise so long as adequate servicing is lacking.

**RADAR** beacons, despite all the nice things their manufacturers have to say about them, are making life miserable for the test engineers who have to depend on them for tracking missiles and satellites. A number of SPACE/AERONAUTICS readers from Cape Canaveral, Fla., and White Sands, N.M., have complained about unreliable beacons. Most failures are either catastrophic or due to frequency drift.

**LEADER** cable system for approach and landing has been suggested by Ross Gunn, consulting research physicist at American U., Washington, D.C. It would use a copper conductor, either buried or mounted on poles in the approach zone. Gunn hasn't revealed how far out in front of the runway the conductor would have to be. However, if its design bears any resemblance to the British two-cable system, about a mile would be needed.

Gunn told SPACE/AERONAUTICS that the cable could be 50 miles long (or longer) to provide intercity guidance for copters. To use the conductor for guidance, an aircraft would have to be within 2000 ft of it.

**THE** cable would carry an audio frequency current and require 25-50 kw. Three mutually orthogonal induction coils, each about two feet in diameter, would be mounted in the aircraft for sensing. The altitude accuracy of this system, claims Gunn, would be ±50 ft at 1000 ft and as good as six inches at 10 ft above the ground.

**ALL-WEATHER** Operations committee of the Airline Transport Association reported after first meeting that the airlines seem agreed that eventually they will have to go to fully automatic landing. The main job now is to set up a program for getting to that point.

At present it looks as though a four-step evolution will be followed:

- reduce present takeoff limits;
- reduce jet minimums to the level of piston minimums;
- make it possible to go safely down to 50 ft on instruments;
- fully automatic landing.

**MANY** of the ATA committee members believe we ought to have continuous distance information—particularly because then it would be simple to compute good altitude data over rough terrain. The committee also pointed out that, once distance information is available, the automatic approach coupler can be greatly improved.

By way of counter argument it was pointed out that it hasn't yet been determined whether distance from DME at an ILS site is accurate enough for transition to flare. Also, there is so far no provision for installing DME at ILS sites.

A radio altimeter, though it gives accurate indications only over smooth ground, has the advantage of requiring no additional ground facilities, the committee noted. It might be simpler to use for indicating where flare-out should begin.

**ONE** of the goals of the ATA group is to make all-weather landings possible for present as well as future aircraft. Therefore studies must be made of present autopilots and aircraft, with an eye toward any improvements that might be necessary.

**A KEY PROBLEM** in landing today's high speed aircraft, which will greatly influence the design of any future landing system, is that, at today's approach speeds, landing weights, etc., a jetliner is practically committed to land once it reaches its minimums. The transitioning from instrument flight to visual at 150-200 ft is the most critical phase of the approach and is one of the most important reasons why the airlines and the military think that fully automatic landing is a must.

NORD-AVIATION
Ordnance
Research
Development

RAMJET
POWERED
NORD
GRIFFON·02

Nord's Griffon-02, in a series of record-breaking flights, paves the way for supersonic transport. Its unique ramjet-turbojet engine is the first step in developing the needed economical power plant.

The flights of the Griffon-02 earned for its pilot, Major André Turcat, the coveted Harmon International Trophy in 1959 for "outstanding achievements in aeronautics".

NORD-AVIATION

2-18, rue Béranger
CHATILLON-SOUS-BAGNEUX
(Seine) France

Write in No. 190 on Reader Service Card

←Write in No. 189 on Reader Service Card

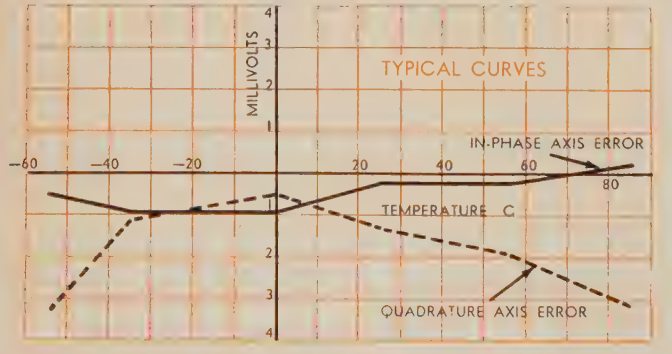
# New Ketay size 15 integrating motor tachometer —

- REQUIRES NO WARM-UP TIME
- USES NO HEATERS
- HAS 1.0000 VOLT PER 1000 RPM OUTPUT GRADIENT OVER ENTIRE TEMPERATURE RANGE

The Ketay integrating motor tachometer, Type 105P2Y has many features that assure high output-to-null voltage ratios and extreme accuracy over the entire temperature range of —55°C. to +80°C.

In addition, the Type 105P2Y will give instantaneous response, for no warm-up time is required at any temperature within the operating range. The Ketay design uses no heating elements, mechanical thermostats, amplifiers or external heat sources and, as a result, the unit has increased life, less weight and less power drain on the over-all system.

The unit will pass military environmental specifications called out in MIL-S-17806.




## CHECK THESE GENERATOR SPECIFICATIONS:

| | |
|---|---|
| Excitation (volts) | 115 |
| Frequency (cps) | 400 |
| Input current (nominal) amps | 0.0275 |
| Input power (nominal) watts | 1.9 |
| Output gradient per 1,000 RPM @ 25°C. | 1.0000 ± .05% |
| Phase shift with respect to input at 3600 RPM @ 25°C. | 0° ± 10′ |
| Null voltage at 25°C. (Maximum Values) | |
| IN-phase Fundamental at zero speed | 2MV |
| Quadrature Fundamental at zero speed | 6MV |
| Total harmonic | 10MV(RMS) |
| IN-phase axis error | 1MV |
| Quadrature axis error | 1MV |
| Linearity —0 to 4000 RPM (percentage of voltage output at 3600 RPM) | ± .06% |
| Variation in output gradient with variation in ambient temperature (—55°C. to +80°C.) | ± 0.2% |
| Variation in axis error with variation in ambient temperature (—55°C. to +80°C.) | ± 7MV ± J8MV |
| Variation in phase shift with variation in ambient temperature (—55°C. to +80°C.) | ± 1° |
| Warm-up time | None |
| Total unit weight (motor and generator) | 15 oz. |

Write for detailed specifications and drawings, or for information on other Ketay integrating and damping tachometers.

**KETAY DEPARTMENT**

NORDEN
DIVISION OF UNITED AIRCRAFT CORPORATION
Commack, Long Island, New York

Write in No. 191 on Reader Service Card at start of Product Preview Section

space/aeronautics

CONFIDENTIAL

June 1960
(good until 8/15/60)

# Employment Inquiry Form

(Not an application for employment)

**THIS INQUIRY FORM** is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

**(1)** Tear out this page.

**(2)** Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

**(3)** Turn to the back page of this Form and answer the questions on it.

**(4)** Mail this Form (in a stamped envelope) to:

Reader-Service Dept.
**SPACE/AERONAUTICS**
205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements they will get in touch with you at your home.

---

I am interested in the employment opportunities at:

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| ☐ Convair; Astronautics Engrg. Div. | 141, 142 | ☐ Space Technology Labs. | 27 |
| ☐ Marquardt Aircraft Co. | 209 | ☐ System Development Corp. | 208 |
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OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.) : _____

_____

_____

**NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.**

space/aeronautics

CONFIDENTIAL

June 1960
(good until 8/15/60)

# Employment Inquiry Form

Please type or print (with pencil)

(NOT an application for employment)

**FIELDS OF INTEREST** (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

**SPECIALIZED JOB EXPERIENCE** (describe the specific technical areas in which you have worked —e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

## JOBS AND EDUCATION

List your last 3 employers:

| EMPLOYER | CITY & STATE | YEARS EMPLOYED | JOB TITLE OR FUNCTION |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

List your college and university degrees:

| SCHOOL | YEARS ATTENDED | DEGREE |
|---|---|---|
| | | |
| | | |
| | | |

Special Training _____

## PERSONAL DATA

AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone: .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.

Check Employment Inquiry Form Page 205 ➡

# ATTENTION ALL ENGINEERS

If you are seeking new job opportunities be sure to read all employment advertisements in this issue—both in this Special Section and throughout the magazine

*electrical or mechanical engineers*

# INTERESTING DIVERSIFIED HIGH-LEVEL POSITIONS

Honeywell introduced the first successful autopilot of World War II—the C-1. Since then we have produced more flight control systems than any other company. Today we are engaged in producing the automatic flight control system and the rate stabilization control system for Project Mercury, the flight reference system for the Titan, the solid state autopilot for the F-104, and the adaptive autopilot which controls flight through aerodynamic surfaces and reaction nozzles for the X-15.

One result of our X-15 Adaptive Autopilot effort has been the creation of a permanent reaction control system and development section which has been assigned to our Components Design Department.

Because of our expansion in this area we now have openings for engineers with the following background and experience.

## REACTION CONTROL SYSTEMS ENGINEERS

Requires background in missile propulsion systems analysis as it relates to reaction controls. Must be able to establish reaction control requirements by analysis of vehicle dynamics and have an understanding of propellant fuels and oxidizers for specific systems; handle heat transfer problems to optimize and compare several concepts for a given duty cycle; determine optimum over-all performance characteristics, thrust response with given inputs, and chamber pressure and oxidizer-fuel ratios for various nozzle heat sink designs; assist on all proposal efforts requiring propulsion system analysis.

## REACTION CONTROL DEVELOPMENT ENGINEERS

Requires background in rocket engine design, specifically bipropellant type. Must be capable in valving design techniques for injection mixing, oxidizer to fuel ratio adjustment, positive shut-off and valve actuation methods, determining thrust at sea level and vacuum with various fuels and combustion chamber designs. Must have working knowledge of high temperature materials and materials compatible with exotic fuels and oxidizers; ability to determine the optimum configuration (nozzle, valves, torque motor, injectors, etc.) for given applications; ability to work with design and layout draftsmen, model makers, and evaluation engineers in following through with a design development.

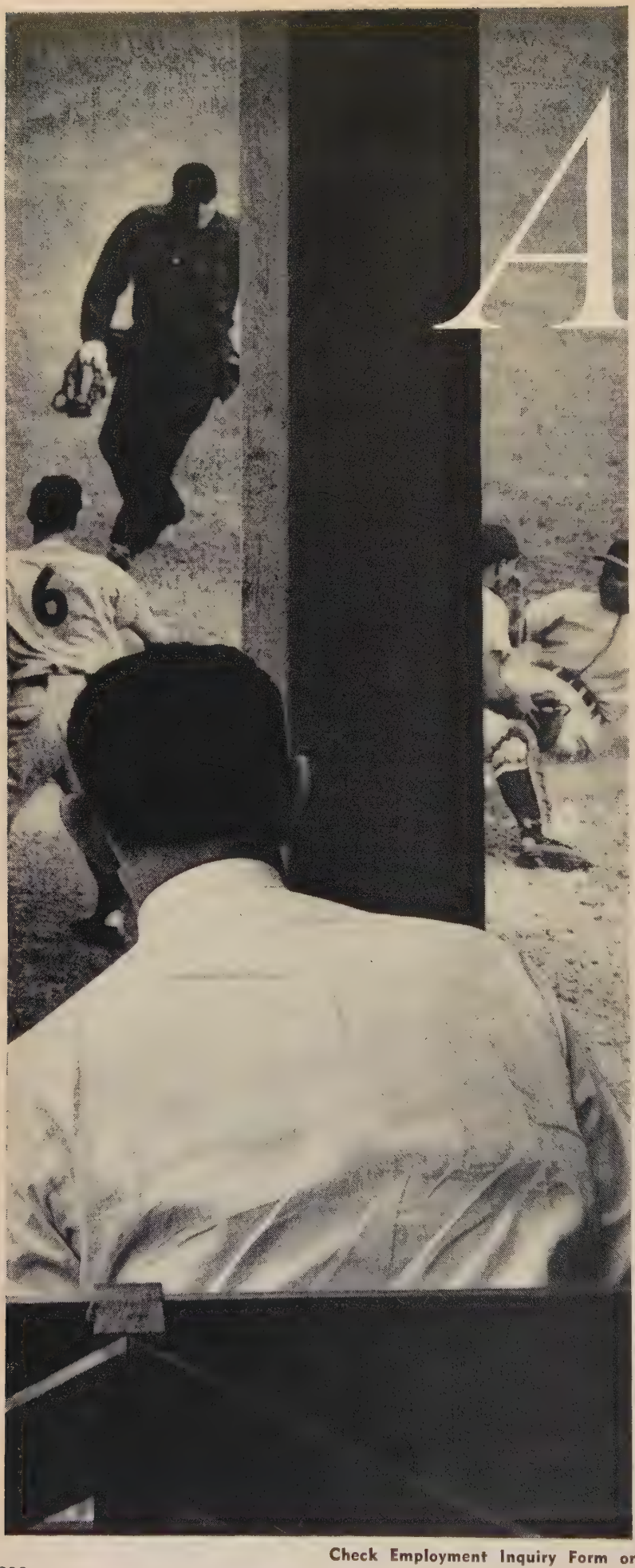
*If you are a qualified engineer, we would like to hear from you. Just drop a line including pertinent information on your background, interests, and accomplishments to Mr. James B. Burg, Dept. 663C, Honeywell Aeronautical Division, 1433 Stinson Blvd. N.E., Minneapolis 13, Minn.*

**Honeywell**

H HONEYWELL *Military Products Group*

To explore professional opportunities in other Honeywell operations coast to coast, send your application in confidence to H. K. Eckstrom, Minneapolis 8, Minnesota.

Check Employment Inquiry Form on Page 205



# Analytical Engineers:

## *Want to see the whole picture?*

Some engineers are content to stay in their own technological backyards. But many others prefer to work in an inter-disciplinary environment, where everything they do is concerned with the total system.

If you are interested in seeing and understanding the whole picture, rather than just a small segment of it, we think you'll be interested in System Development Corporation. Our work is concerned with the design and development of extremely large systems in which high-speed digital computers aid men in decision-making. The relative capabilities and roles of men, machines, and associated system components pose intriguing problems for creative minds.

At the present time we have key openings at Lodi, New Jersey and Santa Monica, California for engineers with proved analytical ability in the areas of communications, computers and associated equipment, simulation, information theory, weapons system analysis. Please send your inquiry to Mr. William S. Keefer, SDC, 2424 Colorado Avenue, Santa Monica, California.

"A Mathematical Model of an Air Defense Operation and a Method of Evaluation," a paper by SDC's staff, is available upon request. Please address inquiries to Mr. W. S. Keefer at SDC.

SDC

**SYSTEM DEVELOPMENT CORPORATION**

*Santa Monica, California • Lodi, New Jersey*

11-1402

**Check Employment Inquiry Form on Page 205**

PROFESSIONAL PERSONNEL REQUISITION

**NUCLEAR SYSTEMS DIVISION** of The Marquardt Corporation is engaged in a continuing search for engineers and scientists capable of contributing to advances in nucleonics state-of-the-art. Current expansion within this division creates challenging opportunities for professional personnel with B. S. and advanced degrees and experience in the following fields:

**Reactor Physics and Shielding**
**Nuclear and Ceramics Engineering**
**High Temperature Metallurgy**

Write in confidence to: Mr. Floyd Hargiss, Manager
Professional Personnel, The Marquardt Corporation
16555 Saticoy Street, Van Nuys, California

THE Marquardt CORPORATION

Corporate offices: Van Nuys, California
Operations at: Monrovia, Pomona, Van Nuys, California — Ogden, Utah

Check Employment Inquiry Form on Page 205



# Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn gives your request immediate consideration.

Check the "Employment Inquiry" form for details.



# INERTIAL SYSTEMS DEVELOPMENT

. . . . . there are opportunities at Honeywell Aero for the engineer or scientist who is interested in participating in this growing field of technology. While specific inertial systems experience is desirable, you may also be qualified by your background and/or related experience for activities in the inertial systems development at this time. Specific openings include:

**SYSTEMS ANALYST**

Mathematician or engineer with strong background in vector analysis, operational calculus, matrix algebra and related techniques. To carry out analysis of inertial systems configurations including error evaluation.

**DIGITAL SYSTEMS AND LOGIC DESIGNER**

Familiar with digital logic techniques at current state of the art; capable of organizing computing systems to perform various tasks including logical design and critical parameter specification.

**ELECTRONIC ENGINEER**

Electrical engineering degree plus experience in miniaturized semiconductor electronics development. To design servo, pickoff, and other electronics for use with gyros and accelerometers.

**ENGINEERING PHYSICIST**

Physicist with practical and theoretical understanding of mechanics, magnetism and electricity to analyze and develop inertial sensors of novel and original design.

*To discuss these or other openings, write Mr. R. O. Maze, Chief Engineer, Marine Systems Group, Dept. 663B, Aeronautical Division, 1433 Stinson Blvd., Minneapolis 13, Minn.*

**Honeywell**

H Military Products Group

*To explore professional opportunities in other Honeywell operations coast to coast, send your application in confidence to H. K. Eckstrom, Honeywell, Minneapolis 8, Minnesota.*


Check Employment Inquiry Form on Page 205

# CALIFORNIA

# AGAIN THE LAND OF PROMISE

Science has brought us to a unique vantage point from which we can foresee vast technological change. As the curve of scientific progress approaches the vertical, today's pioneers who wish to contribute significantly in their chosen fields will do well to consider the unequalled challenge offered by association with one of the nation's foremost scientific laboratories. Positions are currently available in physics, electronics, mathematics, and in mechanical and aeronautical engineering, as well as in other technical disciplines.*

The diverse locations of the Naval Laboratories . . . the varieties of climate and recreation . . . assure your discovery of life as you want it. Address your inquiry to:

## U. S. NAVAL LABORATORIES

*in California*
*Personnel Coordinator, Dept. E*
*1030 East Green Street*
*Pasadena, California*

- **The Pacific Missile Range and U. S. Naval Missile Center, Point Mugu:** National launching and instrumentation complex, guided missile test and evaluation, astronautics, satellite and space vehicle research and development.
- **U. S. Naval Ordnance Test Station at China Lake and Pasadena:** Developers of guided missiles, rockets, advanced propulsion systems, torpedoes, and other undersea weapons.
- **U. S. Naval Ordnance Laboratory at Corona:** Developers of guidance and telemetry systems and other missile system components. Researchers in such fields as IR spectroscopy, magnetism and semiconductors.
- **U. S. Naval Radiological Defense Laboratory at San Francisco:** The nation's only major center for research on nuclear effects and development of counter measures.
- **U. S. Navy Electronics Laboratory at San Diego:** One of the Navy's largest organizations engaged in the research and development of radar, sonar, radio and acoustics.

*These positions are in the Career Civil Service.

Check Employment Inquiry Form on Page 205

# He juggled the hottest potatoes in the Seawolf

...the fuel elements for its nuclear power plant.

Periodically, spent elements must be removed and replaced with fresh ones. The problem—utterly original and fiendishly difficult—was to do the job safely, quickly, and, above all, surely.

This AMF engineer designed the refueling system that did the job. One of his major problems was the fuel elements' liquid sodium environment. Sodium burns fiercely when brought in contact with either air or water. Yet, it had to be exposed during element transfer. Solution: an inert helium blanket to isolate the sodium.

Though awesomely intricate, the refueling machinery had to be designed to work in cramped quarters. The high radioactivity of the environment made the handling problem still more difficult.

That's why, though remotely controlled, all apparatus is *manually* operated. It removes the element and transfers it to a disposal container with complete safety, accuracy, and a degree of reliability that approaches the supernatural.

**Single Command Concept**

The solution of this first-time-in-history problem is one more example of AMF's resourcefulness.

AMF people are organized in a *single operational unit* offering a wide range of engineering and production capability. Its purpose: to accept assignments at any stage from concept through development, production, and service training... and to complete them faster...in

- *Ground Support Equipment*
- *Weapon Systems*
- *Undersea Warfare*
- *Radar*
- *Automatic Handling & Processing*
- *Range Instrumentation*
- *Space Environment Equipment*
- *Nuclear Research & Development*

GOVERNMENT PRODUCTS GROUP, AMF Building, 261 Madison Avenue, New York 16, N. Y.

AMF

engineering and manufacturing AMF has ingenuity you can use...

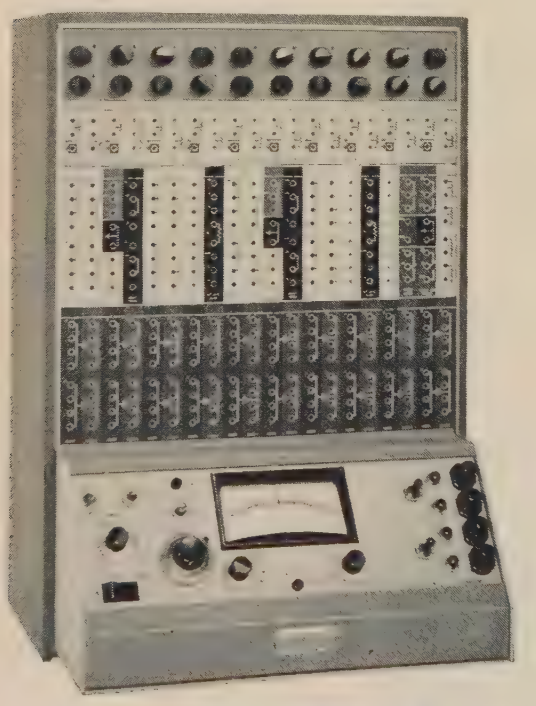
**AMERICAN MACHINE & FOUNDRY COMPANY**

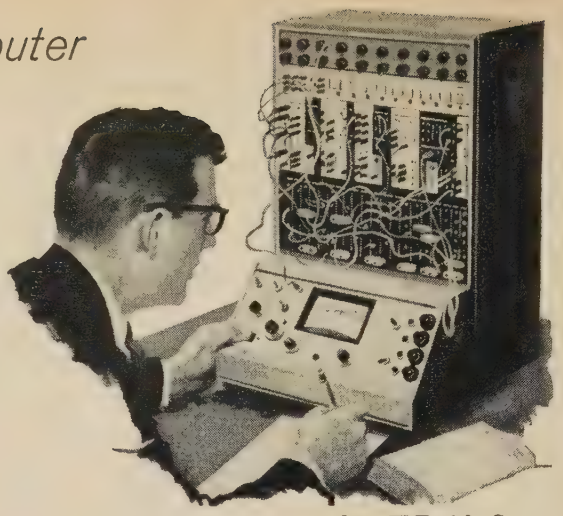
Write in No. 285 on Reader Service Car

**EAI** *Transistorized Analog Computer*

# A WIDE RANGE OF SOLUTIONS AT DESIGN ENGINEERS' FINGERTIPS...

PACE® TR-10, the first all transistorized desktop analog computer, puts proven high-speed computation right where it's needed – on the desks of busy engineers. With this easy-to-use simulator, you can quickly solve many problems without waiting for scheduled access to large-computing systems. Though compact in size, the TR-10 is a full-fledged analog computer capable of providing solutions to a wide range of design problems. Up to 20 amplifiers, plus linear and non-linear computing components are contained in one compact cabinet with no external racks. The TR-10 permits rapid evaluation of different design approaches. It demonstrates the performance of a conceptual or drawing-board design prior to construction. Thus it saves time and money normally required for multiple test models with cut-and-try engineering.





*Here's How The TR-10 Saves Engineering Time*

The TR-10 is especially useful in solving problems in such diverse areas as servo-system design, heat flow, chemical reaction analyses, suspension systems studies and many other problems involving dynamic conditions. Fast answers to problems posed by new design ideas immediately determine feasibility of projects. With the TR-10, engineers can explore new ideas as they occur – concentrate valuable time on the most promising area of study.

*(Applications notes are available describing typical problem solutions.)*

*How Do You Use The TR-10?*

*First*—Represent in equation form the physical system to be studied.

*Second*—Select through a simple computer diagram the computing components required to perform the calculation (programming).

*Third*—Interconnect these components on the computer (problem patching) and set problem parameters with adjustable controls.

*Fourth*—Run the problem with results presented graphically on an accessory recorder or oscilloscope.

You now have an electronic analog *model* of the physical system under study. You can manipulate design parameters quickly, running comparative solutions without becoming involved in repeated calculations. With the TR-10 you can rapidly develop truly optimum designs.

For complete details of TR-10, write for free copy of Bulletin AC934–BA.

**PACE TR-10** Analog Computer, including components for addition, subtraction, multiplication, division, integration and generation of powers, roots, logs, antilogs and arbitrary functions.

**EAI** ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

Write in No. 192 on Reader Service Card at start of Product Preview Section

# product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, definitions and cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader Service Card.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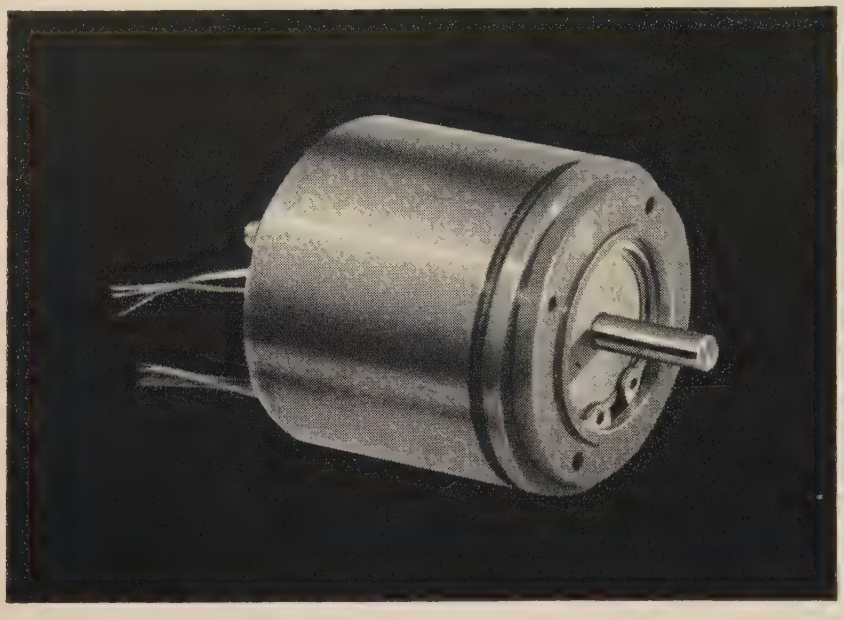
ENGINEERING
REPORT
ON BENDIX COMPONENTS



# ONE-MINUTE SYNCHRO SYSTEM ACCURACY

Electrical two-speed Autosyn* synchro features—

- **ACCURACY UNAFFECTED BY THERMAL AND MECHANICAL STRESS**
- **HIGH SIGNAL-TO-NULL RATIO**
- **ELIMINATION OF GEAR ERROR FOUND IN MECHANICAL TWO-SPEED SYSTEM**
- **ADAPTABILITY TO GYRO PICKOFF**

Developed to meet need for accurate data transmission with maximum system simplicity. Produces two electrical outputs from single shaft, thereby eliminating inaccuracies of two-speed gear system as well as installation and maintenance costs of additional unit.

The synchro contains two separate sets of windings. One set produces the normal signal pattern of one cycle of output voltage, while the other produces eleven cycles, for each rotation of the synchro shaft. Increase in accuracy is very close to the 11-to-1 theoretical maximum, resulting in a system error of ±1 minute when used back-to-back with similar units.

*REG. U. S. PAT. OFF.

**ADDITIONAL CHARACTERISTICS:**

| | |
|---|---|
| Input voltage (to rotor) | 26 volts, 400 cycles, single phase |
| Input current | 200 ma max. |
| Input power | 2.5 watts max. |
| Signal-to-null ratio | 350:1 |
| Sensitivity (mv/degree) | 3500 |

For more detailed information on specific applications, write—

Eclipse-Pioneer Division
Teterboro, N. J.

District Offices: Burbank and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

**Write in No. 193 on Reader Service Card at start of Product Preview Section**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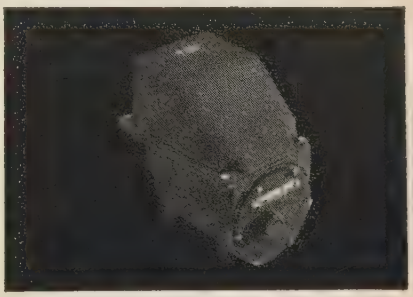
(Training Service Division), 250 S. Prairie Ave., Hawthorne, Calif.

Dept. H-6

ENGINEERING REPORT ON OTHER BENDIX COMPONENT PACKAGES

**BAROMETRIC ALTITUDE CONTROL**

**Maintains aircraft altitude in automatic flight systems.**



This Eclipse-Pioneer pressure-sensing instrument helps maintain aircraft at a selected altitude in automatic flight. Sensing barometric altitude, it generates electrical control signals whenever the aircraft is displaced from the reference. These signals, proportional to the deviation, are power amplified and provide a control signal to restore correct altitude. Write for details.

**VERTICAL SENSOR**

**Indicates true vertical positioning within ±3 minutes of arc.**

Eclipse-Pioneer's Vertical Sensor is a small (4⅞" high), lightweight instrument for highly accurate determination of vertical positioning. An iron pendulum is suspended in a tube of damping fluid. Two magnetic pickups, 90° apart at the bottom of the tube, detect deviation from vertical by sensing movement of the pendulum from center. Output increases linearly as the unit tilts from vertical, and cross coupling is minimal. Ask for further information.

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Teterboro, N. J.

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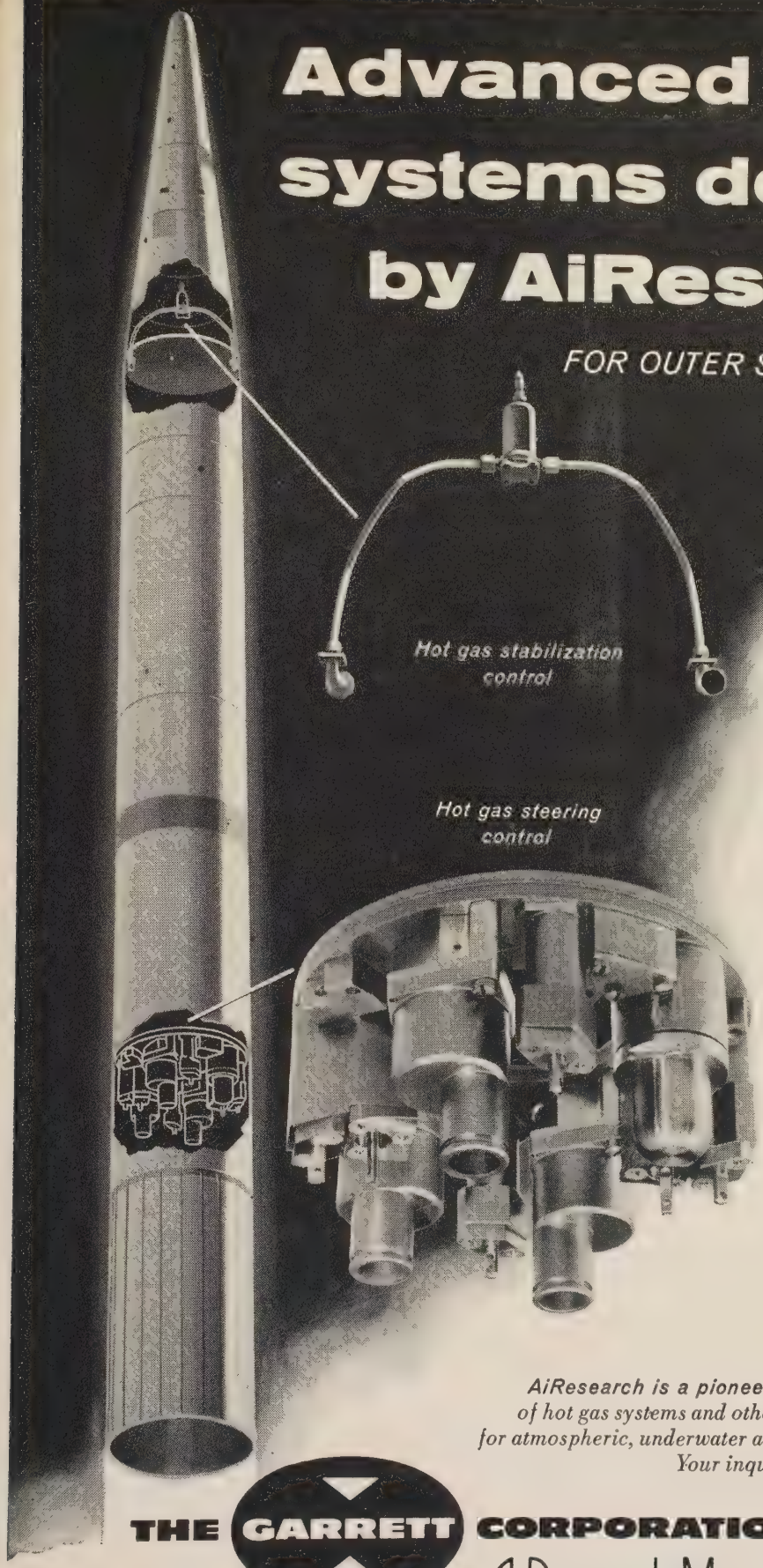
# Advanced hot gas systems delivered by AiResearch

## FOR OUTER SPACE, ATMOSPHERIC AND UNDERWATER STEERING




AiResearch is now in production on two greatly simplified hot gas steering control systems: a reaction control system for outer space flight stabilization and a hot gas actuator control system for terrestrial steering (in the atmosphere and under water).

Both systems eliminate any need for pumps, heat exchangers, accumulators and other apparatus required in earlier control systems. And both systems utilize hot gas, operating off either the main engine or a separate fuel source.

The gas in the outer space reaction control system is fed into a set of nozzles which imparts spin to the missile to stabilize its flight through space.

In the terrestrial hot gas actuator control system the gas is fed into an on-off controlled linear actuator which moves the fins controlling the missile's attitude in the atmosphere or under water. This system also utilizes a concept developed from the AiResearch hydraulic "printed circuit." This approach eliminates complicated plumbing, thereby decreasing the weight and increasing the reliability of the system.

*AiResearch is a pioneer, leading developer and manufacturer of hot gas systems and other nonpropulsive power systems for atmospheric, underwater and outer space missions. Your inquiries are invited.*

**THE GARRETT CORPORATION**

AiResearch Manufacturing Divisions

*Los Angeles 45, California • Phoenix, Arizona*

*Systems, Packages and Components for:* AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

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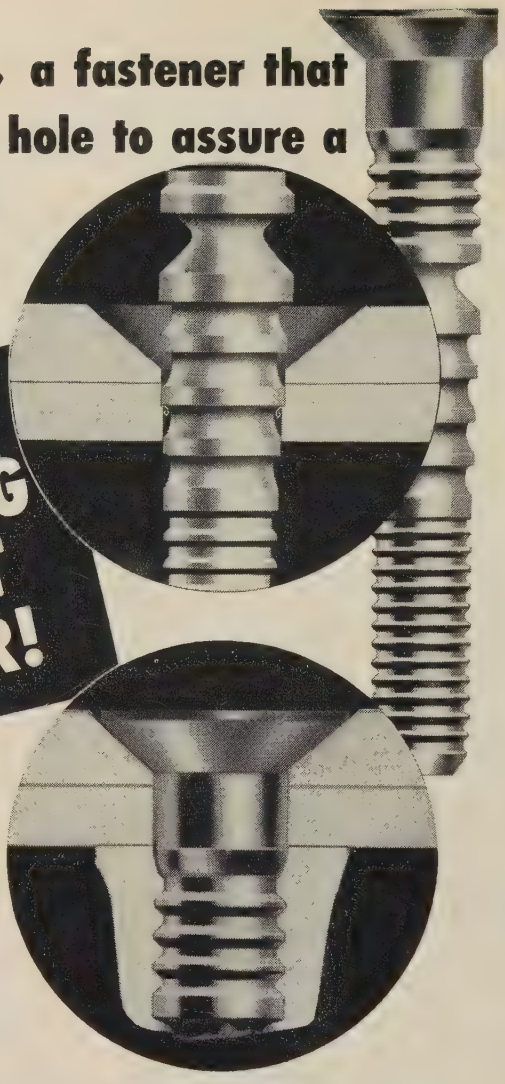
# *now*... a fastener that broaches its own hole to assure a positive, uniform interference fit



## The SELF-BROACHING HUCKBOLT FASTENER!

**A fast, dependable answer to fastening problems where close tolerance and self-sealing are required.**

**Originally designed to seal liquid oxygen compartment bulkheads in Thor missiles.**

**The Self-Broaching Huckbolt Fastener is the latest development in Huck's front-running research program which provides new and better fasteners for industry. Broaching teeth, added to Huck's standard AL (Aircraft Huckbolt) fastener, enable this alloy steel fastener to finish-broach its own pre-drilled hole during installation. A tight mechanical seal is formed between the installed fastener and its undersize hole.**

**Unique features:**

- **Broach handles *all hole* preparation**
- **Dependable sealing without gaskets or sealant**
- **Lower installed cost, faster installation**
- **Can be installed "dry"**
- **Uniform shear and tension**
- **Uses standard Huck installation tools**
- **Removes up to .01 inches of hole material**
- **Protruding or countersunk head styles**

*Let an experienced Huck Fastening Engineer help with your fastening problems.*

**HUCK MANUFACTURING COMPANY**

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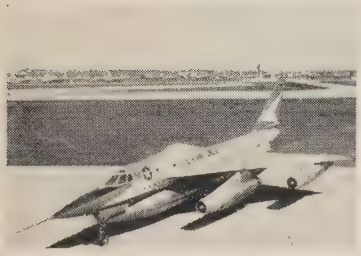
* In International Edition only.

Installation of flexible fire seal in wing of B-58. Fabric coated with VITON synthetic rubber will resist up to 500° F. Other use. for this new heat and chemical resistant rubber: O-rings, gaskets, hose and tubing, diaphragms and a host of molded parts for engines, instruments, transmissions.

# HOW VITON® BEATS THE HEAT AT MACH 2

**Asbestos coated with new fluorocarbon rubber takes 500° F. temperatures in fire seals for B-58**



Convair pioneered the use of elastomer-coated asbestos fire seals for equipment access tunnels in the wings of the B-36. But the new B-58, traveling at Mach 2 speeds, presented a more difficult problem—higher operating temperatures.

Convair had to find a fire seal material that would stay flexible at 500° F. temperatures. They found it—Du Pont's new VITON synthetic rubber. Asbestos coated with this elastomer not only stood up to Mach 2 heat requirements, but gave the needed resistance to ozone, jet fuels, fumes, corona, pressure and vibration as well.

VITON meets government specification MIL R25897 for a high-temperature, fluid-resistant synthetic rubber for aeronautical application. This VITON-coated fabric actually performs better than aluminum would; it is equivalent to *stainless steel* in retarding the transfer of heat, according to Civil Aeronautics Administration specifications.

Where can *you* use VITON's remarkable combination of properties? It stays elastic for long periods at temperatures as high as 600° F. . . . resists chemicals, solvents, fuels, lubricants . . . even at elevated temperatures. It's worth investigating; write for complete technical information to: E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department SA-6, Wilmington 98, Delaware.

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REG. U. S. PAT. OFF.

**SYNTHETIC RUBBER**
NEOPRENE HYPALON® VITON® ADIPRENE®

**Better Things for Better Living . . . *through Chemistry***

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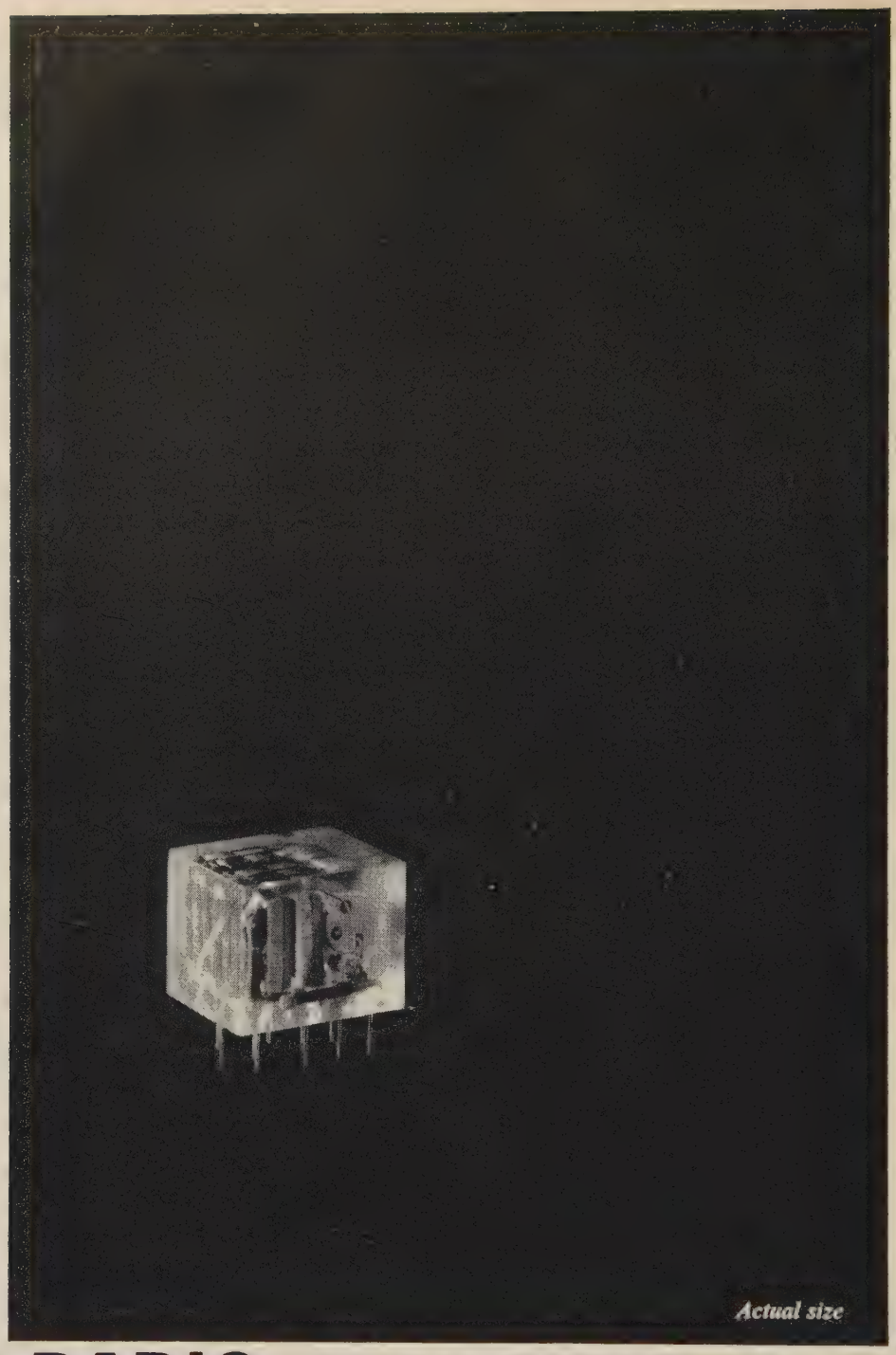


# FROM DELCO RADIO NEW IDEAS FOR DEFENSE

## *MINIATURE MODULES WITH STANDARD COMPONENTS*

They are *building block modules*. They are a product of Delco Radio's newly developed, three-dimensional packaging technique. They are used to build light, compact, reliable airborne and special purpose digital computers for missile control. Each module, vacuum encapsulated with epoxy resin, contains up to 35 standard components per cubic inch—averaging more than 50,000 per cubic foot. The modules perform all the standard logic functions. They meet or exceed all MIL-E-5272D (ASG) environmental requirements and will operate over a temperature range of −55°C to +71°C. They can be assembled in groups on printed circuit boards. There are 10 basic types and 15 variations of Delco Building Block Modules. With them, Delco Radio can quickly and easily build a compact, reliable computer for airborne guidance or any other military application. For complete details, write to our Sales Department. *Physicists and electronic engineers: Join Delco Radio's search for new and better products through Solid State Physics.*

PIONEERING PRECISION PRODUCTS THROUGH SOLID STATE PHYSICS

DELCO RADIO

*Division of General Motors • Kokomo, Indiana*

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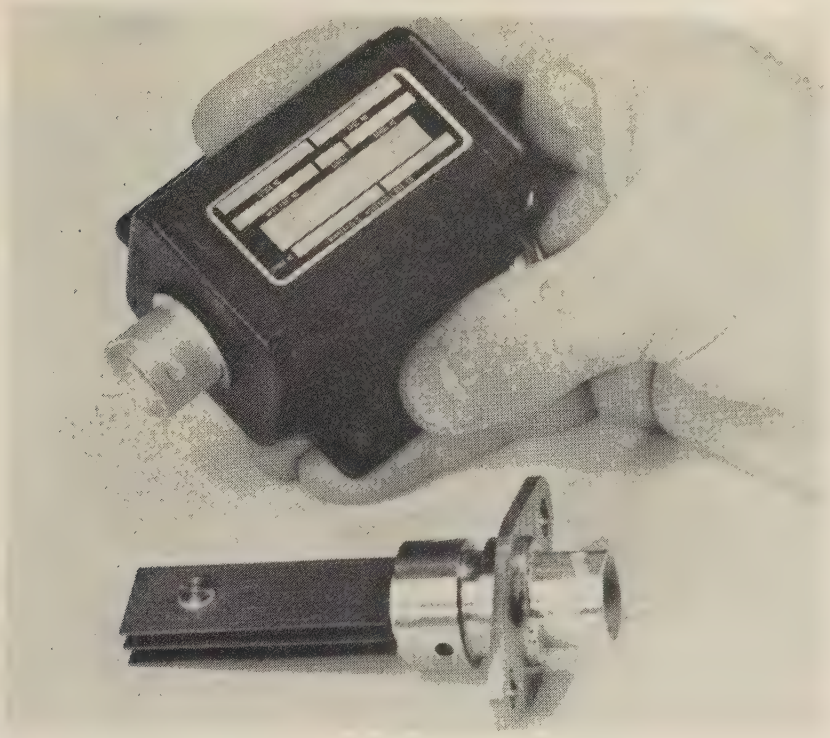
# equipment briefs



## LIQUID-LEVEL SENSOR

A MINIATURIZED, capacitance-type liquid-level sensing system has been developed by Minneapolis-Honeywell Regulator Co., Aeronautical Div., 2600 Ridgway Rd., Minneapolis 13, Minn., for use on aircraft, missiles, and ground-support equipment. Made of a control unit and a capacitance sensor, it can be used with all common fuels and oxidizers. According to M-H engineers, the cable connecting the two units may be of virtually any length without affecting operation.

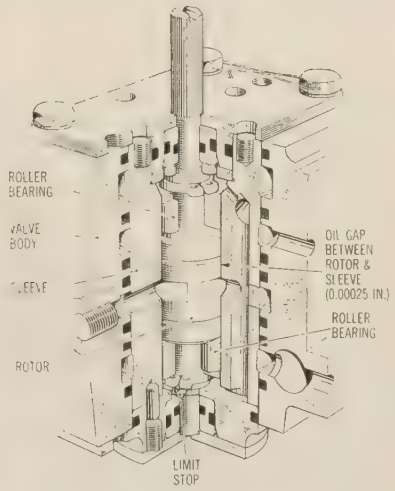
A typical system weighs about 5½ oz. The sensors operate over a wide temperature range — from liquid hydrogen (—420 deg F) to 1100 deg F. They can be provided for flange, bulkhead, internal, and in-line mounting. Response time for the system reportedly can be varied from 10 millisec to four seconds with an accuracy of ±0.05 in.

The control unit contains a two-stage transistor amplifier, a single-stage relay amplifier, a relay, and a reference capacitor. Solid-state switching is optional. Power consumption, M-H claims, is only 0.33 W on dc systems and 0.5 W on ac systems. Write in No. 55 on Reader Service Card for more information.

## INSPECTION TEMPLATE FOR HONEYCOMB PANELS

A CHECK template has been developed by Aeronca Manufacturing Corp., Middletown, Ohio, to measure the length, height, and flange width of U-channels for B-58 honeycomb panels. The template has reduced inspection time from fifteen minutes (with a snap gage) to six minutes per unit.

The template checks the web to 0.003 inches, length to 0.003 inches, and flange width to 0.15 inches. It can be used for seven different channels.




## ROTARY CONTROL VALVE

A rotary control valve, developed by Boulton Paul Aircraft Ltd., Wolverhampton, England, features a very fine gap between rotor and sleeve. This gap prevents contact between the two surfaces and so reduces the possibility of sliting. Since only an extremely small amount of fluid flows through the gap and leaks back to the sump, pressure does not build up in the valve body.

Static forces on the valve are balanced by the diametrically opposed ports. Dynamic forces on the rotor are in opposite directions for inlet and outlet ports. By adjusting the area and shape of the cuts in the rotor, the net force on the valve assembly can therefore be balanced at any desired value. Another important feature is that the overlap and underlap of the control ports can be adjusted for varying sensitivity.

Through careful selection and alteration of these variables, Boulton Paul says, you can match a valve to any particular application. Write in No. 66 on Reader Service Card for more information.

# NEW! ANSCO SUPERPAK

## for the first time, a new x-ray film packaging that saves time and lowers costs at no sacrifice in quality.

Interrupting operations to open small quantities of X-ray film? Handling many small packages and wrappings? Never again with Ansco SUPERPAK. New Ansco SUPERPAK® is the modern way to increase your efficiency through 600 non-interleaved sheet or 300 interleaved sheet packages of Superay 'A' or Superay 'B'.

Whenever the storage bins (SUPERPAK fits standard film storage bins) need refilling, pause for a moment to open SUPERPAK, work on until the job is completed without further interruptions. Just think of the savings in man-hours and money through this new, sensible method of packaging.

**Ansco**
*Superpak*

From every point of view; money, time and general efficiency . . . it makes sense to use SUPERPAK. Ansco, Binghamton, N. Y., A Division of General Aniline and Film Corporation, Manufacturer of World Famous Superay X-ray Films.

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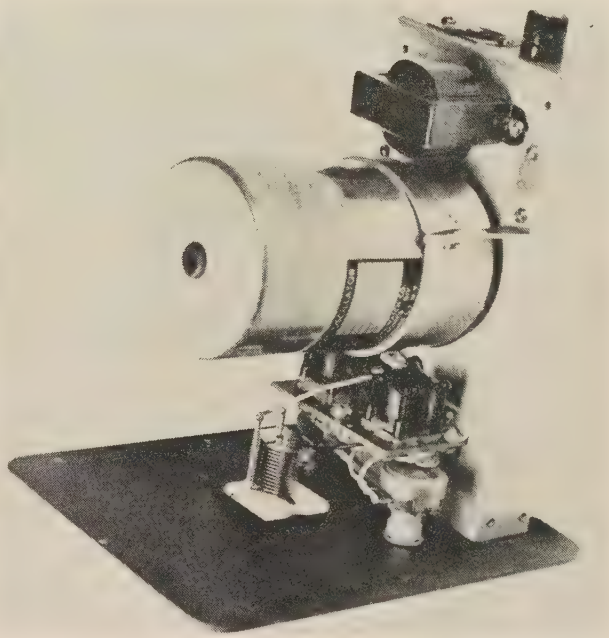


## PORTABLE FREQUENCY STANDARDS for laboratory and field use

JUNE 1960

**Bulova Watch Co., Inc., Electronics Div., 40-01 61st St., Woodside 77, N. Y.,** has developed several types of quartz-crystal frequency standards suitable for lab and field use. Model FS-100 is transistorized and portable, yet maintains a stability of ±1 part in 100,000,000 in any frequency in the range from 10 kc through 20 mc. It has a life expectancy of 25,000 hours with minor maintenance, Bulova engineers claim.

The FS-100 series also includes a model with a frequency range from 50 kc through 10 mc and a stability of ±1 part in $10^9$. Both models are available with a self-contained, rechargeable battery source good for 10 hours. They provide an output of one volt peak-to-peak into a one-kilohm sine or square wave. Input is 115 V ac, 30-1200 cps, at 500 ma maximum. These units measure 6x8x8 in. and weigh 12 lb.

**Write in No. 200 on Reader Service Card at start of Product Preview Section**

*This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of the aerospace industry.*

Randolph Hawthorne
*Editor*

# product preview

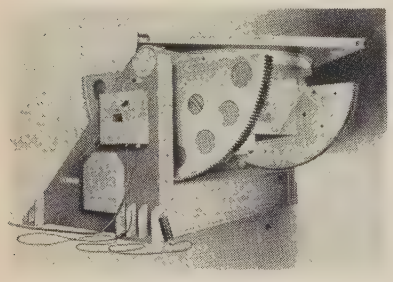
### ANALOG-DIGITAL CONVERTERS for missile use

These extremely rugged shaft position-to-digital converters are suitable for high and low temperature environments with high shock and vibration resistance. Typical units provide for non-ambiguous conversion up to $2^{15}$ in a unit dia less than 1.5 in and length of 1 15/16 in, says **Kearfott Co., Inc., Dept. S/A, 1500 Main Ave., Clifton, N.J.**

The converters are available for a wide range of applications including latitude, longitude, azimuth or conventional angular shaft displacement conversion and for decimal count conversion.

Write in No. 425 on Reader Service Card

### WELDING POSITIONER has 175 tons capacity



This model 3500 welding positioner is rated at 350,000 lbs. capacity at 12 inch center of gravity location. It is shipped completely assembled and tested, says **Aronson Machine Co., Dept. S/A, Arcade, N. Y.** A 4-speed gearshift transmission affords 4 selective variable speed ranges from 0.08 rpm minimum to a fast top speed of .40 rpm.

Applications include fabrication of nuclear reactor vessel components, the maintenance of bells and hoppers for blast furnaces and for welding huge transformer casings.

Write in No. 426 on Reader Service Card

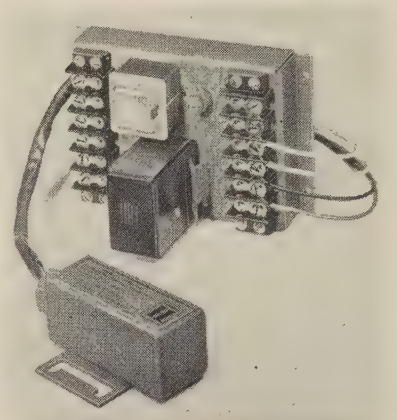
### TIME CODE GENERATOR is transistorized

Time code is supplied as a 14-bit Pt. Mugu code modulating a 1 Kc carrier, and in a dc level shiftform. The basic accuracy of the unit is 10 ppm, says **Electronic Engineering Co. of Calif., Dept. S/A, 1601 E. Chestnut Ave., Santa Monica, Calif.**

One, 5, and 10 pps pulse rates are supplied to the unit as are 3 sine wave outputs at 100, 1000, and 2000 cps and are suitable for recording on magnetic tape. The unit draws 77 watts at 115 V, 400 cps, occupies ½ cu. ft. and weighs only 20 lb.

Write in No. 427 on Reader Service Card

### PROXIMITY SWITCH for severe conditions



This proximity switch is designed for use as limit, interlock, counter or indicator sensors under unfavorable environments such as those created by oil, grit, extreme vibration, dirt or sludge. It detects magnetic material without physical contact and feeds an electrical output to the remotely located bi-stable amplifier, says **Minneapolis-Regulator Co., Micro Switch Div., Dept. S/A, Freeport, Ill.** The amplifier operates the double-pole-double-throw relay, which is wired to the circuit in the same manner as a conventional limit switch.

The two components may be located up to 150 feet apart without the use of shielded wire.

Write in No. 428 on Reader Service Card

### TESTER measures cleanliness

A device that can measure the degree of surface cleanliness where non-bonded soils are involved is being manufactured by **Branson Ultrasonic Corp., Dept. S/A, 40 Brown House Rd., Stamford, Conn.** Typical applications for the CM-1 Cleanliness Tester may include the evaluation of annealing furnace performance, efficiency of electrolytic and alkaline cleaning lines, and use in the plating, organic coating and adhesive bonding industries.

The tester, which has an accuracy of one part in 1000, can indicate the amount of finely divided soils adhering to a surface, as well as check surface freedom from oils. The small, portable device is actually a densitometer that rates for optical density a microscope slide on which is mounted tape that bears soil picked off the surface under inspection. Readings are direct and give a numerical value of zero to 1000 for cleanliness.

Write in No. 429 on Reader Service Card

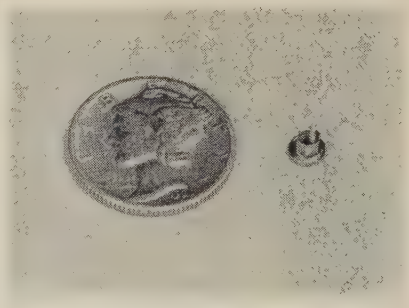
### SERVO MOTOR measures one inch

This size 5 servomotor, one-inch in length, is for use in compact servo mechanisms. The small power package delivers a no-load-speed of 9500 rpm; has stall torque of .09 oz. in. and a theoretical acceleration of 45,000 rad/sec$^2$. Total power input of servomotor is 3.5 W., says **IMC Magnetics Corp., Dept. S/A, 570 Main St., Westbury, N. Y.** The 400-cycle unit will perform in a temperature range of —55 deg C to +150 deg C.

Completely encapsulated in epoxy, the unit is protected against severe shock, vibration, and humidity. Weight is 0.68 oz; diameter, 0.5 in.

Write in No. 430 on Reader Service Card

### HEX NUT takes 160,000 psi



This midget 160,000 psi all-metal, lightweight, self-locking, hex nut is useful for fastener applications in electronic systems of missiles, rockets, and aircraft. Dimensions are: height, .095 in; base dia, .172 in; wrench hex size, 3/32 in; weight, .02 lbs per hundred, says **Kaynar Mfg. Co., Inc., Dept. S/A, Box 2001, Terminal Annex, Los Angeles 54, Calif.**

It is known as Kaylock H14-02.

Write in No. 431 on Reader Service Card

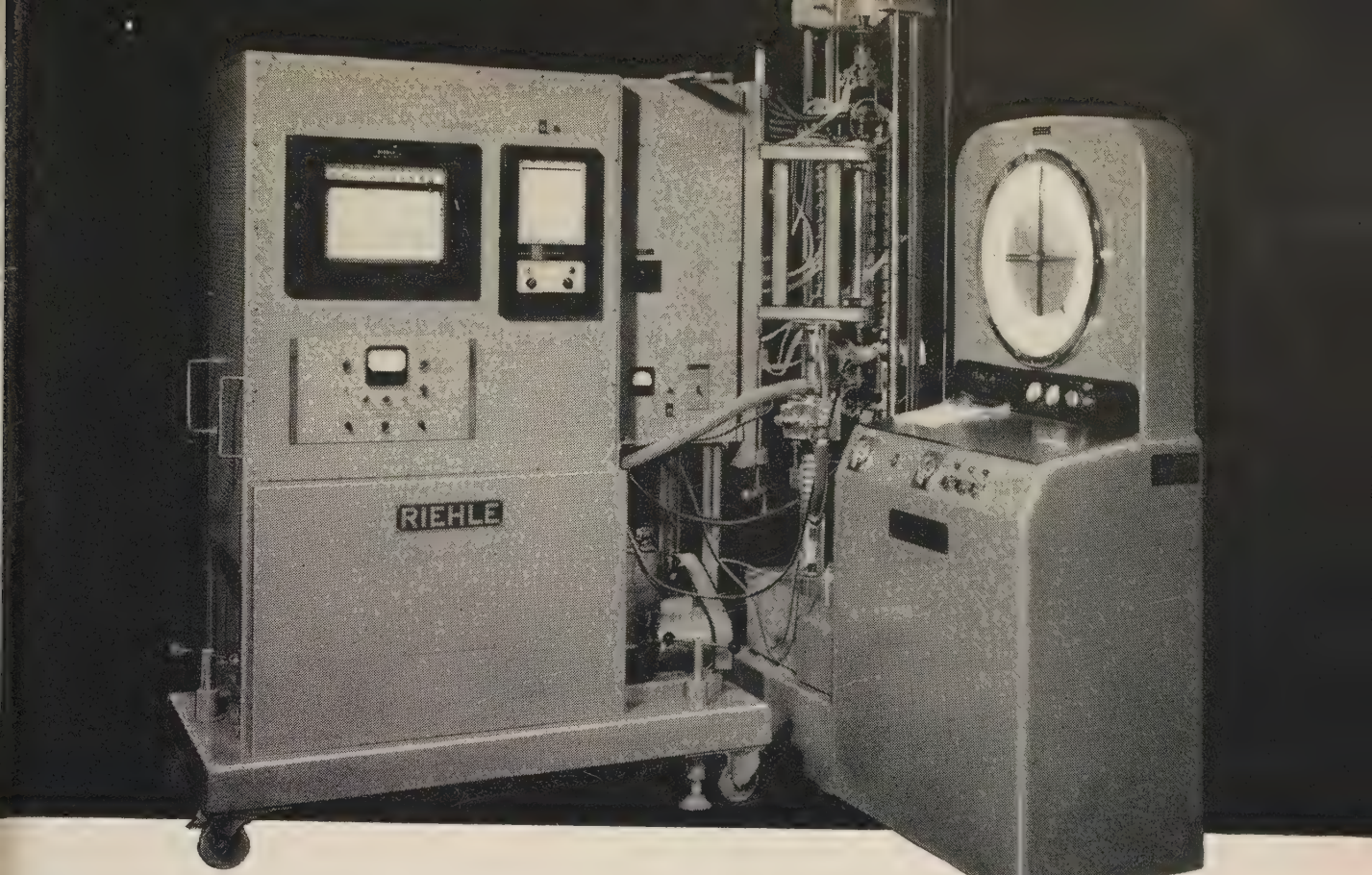
### BOOST PUMP supplies test stands

The Gerotor hydraulic boost pump is designed to provide an instant supply of fluid to high-pressure piston pumps on missile and aircraft test stands to overcome dry starts and pump starvation, says **Double A Products Co., Dept. S/A, Manchester, Mich.** The unit delivers a minimum of 31 gpm at 3450 rpm, using MIL-5606 or 6083 fluids at 160 deg F.

Inlet conditions may range from 125 psi to over 18 in Hg. Model 702 of the pump, which is mounted in direct drive, is supplied with AND 20,001 mounting pad and shaft-end configuration.

Write in No. 432 on Reader Service Card

more on page 226




# Riehle Universal Testing Machines assure maximum versatility for research and control practices

To facilitate modern research and control testing, RIEHLE offers both Screw Power and Hydraulic Testing Machines in capacities from 2000 lbs. to 450,000 lbs. These sensitive and rapid response machines are available with complete instrumentation and accessories including a high temperature vacuum furnace capable of testing materials up to 4000° F.

A full range of holders and specimen tools, automatic strain rate and load rate controls and load cells to extend lower ranges accurately are available. With instrumentation, RIEHLE Testing Machines can be adapted for metals, ceramics, plastics, glass, timber and textiles for virtually any physical test measured in units of load and specimen deformation.

Recommendations for testing procedures and equipment to meet specific requirements will be furnished by RIEHLE engineers on request. Also send now for illustrated catalogs describing RIEHLE Hydraulic and Screw Power Universal Testing Machines and complete Recorders and Accessories.

**OTHER RIEHLE TESTING MACHINES** include Creep and Stress-Rupture Testing Machines, Hydraulic Fatigue Testing Machines, Construction Materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testers and Portable Hardness Testers for Rockwell Readings.

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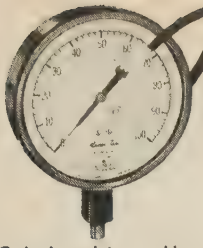
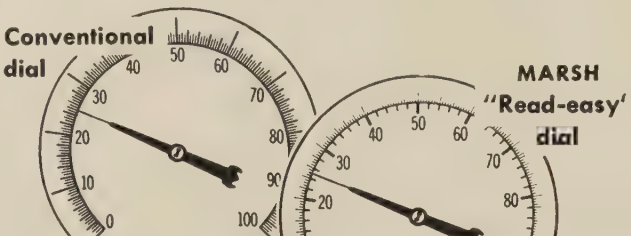
# New MARSH "Master Test" SERIES

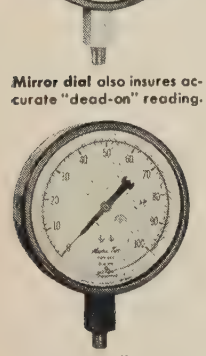


Twin-tip pointer enables observer to read "dead-on" by lining up twin tips like gun sight.

**Unprecedented accuracy and dependability** in test gauges developed to meet today's exacting requirements. Each gauge individually *dead-weight tested!* Guaranteed accurate within ¼ of 1% plus or minus of maximum dial reading over entire range.

Mirror dial also insures accurate "dead-on" reading.



"Non-parallax" dial has Plexiglas insert that assures accurate reading even when read at angle.

**New "Read-easy" dial** (patent pending), as illustrated above, assures reading accuracy in keeping with indicating accuracy. Also note three advanced means of reading available in all "Master-test" gauges: twin-tip pointer, mirror dial, and "non-parallax" dial as shown opposite.

Sizes 4½", 6", 8". All standard pressure ranges 0-15 psi to 0-30,000 psi, vacuum and compound.

*Ask for new 20 page bulletin covering all details*

**MARSH INSTRUMENT CO., Dept. 43, Skokie, Ill.**

*Division of Colorado Oil and Gas Corporation*

Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta

Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

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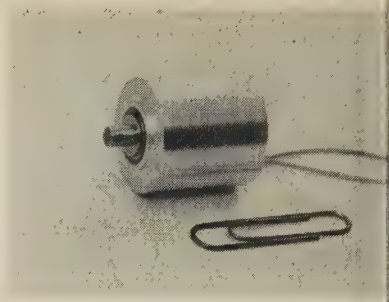
**SOLENOIDS are unrectified**



This linear-magnetic actuator operates without rectification from a 400 ac power source. It is designed for the space-weight-power requirements of the newest space vehicles, and may be used singly or stack-mounted for multiple performance, says **B. H. Hadley, Inc., Dept. S/A, 10681 Santa Monica Blvd., Los Angeles 25, Calif.** Available in two sizes.

It has externally adjustable stroke length and linear action that may be either push or pull. The smaller model 175 weighs 1.3 ounces and consumes 13 watts; the larger model 375 weighs 5.1 ounces and uses 40 watts. Both operate continuously at temperatures from —65 to 450 deg F.

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**more on page 229**

from OHIO

## a new passenger jet aircraft
## EMERGENCY DECOMPRESSION FLOW CONTROL VALVE

A compact, lightweight valve for installation in the emergency oxygen compartment. Valve stands 1⅛" above the manifold and is ¾" in diameter. Total weight is 0.8 oz. Can be individually or manifold mounted.

Valve is actuated when mask is removed from compartment by the passenger. It can be quickly and easily reset. Flow characteristics conform with altitude requirements.

*For complete data and free engineering aid from specialists in aviation oxygen systems, please write to: Aviation Department.*

OHIO Ohio Chemical

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.
Madison 10, Wisconsin
(A Division of Air Reduction Company, Inc.) AIRCO

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# TK test kits

Designed for the flight line testing of jet engine exhaust temperatures, engine temperature spreads, and a variety of gas temperature analysis applications in industry, Harco Test Kit Potentiometers are lightweight, portable, and compact. Shock-mounted, Harco Test Kits offer the built-in accuracy of fully self-contained instruments.

Harco Test Kits incorporate standard cells, galvonometers, and optical amplifiers . . . harnessing to read any number of thermocouples . . . packaged in polished, hardwood cases or military-type trunks.

Four different standard models . . . "specials" to meet individual requirements.

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82 Olive Street, New Haven, Conn.

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***The Checkout that says "GO" or "NO GO"***

# APCHE

*(Pronounced "AP-SHE")*

APCHE (Automatic Programmed Checkout Equipment) is a solid-state, universal, high-speed, highly reliable, compact general-purpose tester designed especially for automatic checkout of aircraft, missile and space systems and their supporting systems. In its various versions (differing in input media, size and weight) APCHE installations may be fixed, mobile, airborne or submarineborne. APCHE was designed and is being produced as a part of RCA's ground support electronics subcontract from the Convair (Astronautics) Division of General Dynamics Corporation, prime contractor for the ATLAS Intercontinental Ballistic Missile.

The system being supplied to Convair for the ATLAS Program includes a console and four rack cabinets providing both analog and discrete test functions with a resulting printed and GO-NO GO indication. As a product of RCA's Missile Electronics and Controls Department, Burlington, Massachusetts, APCHE is one of the latest RCA developments in the field of military weapon readiness equipments.

RCA Tmk(s) ®

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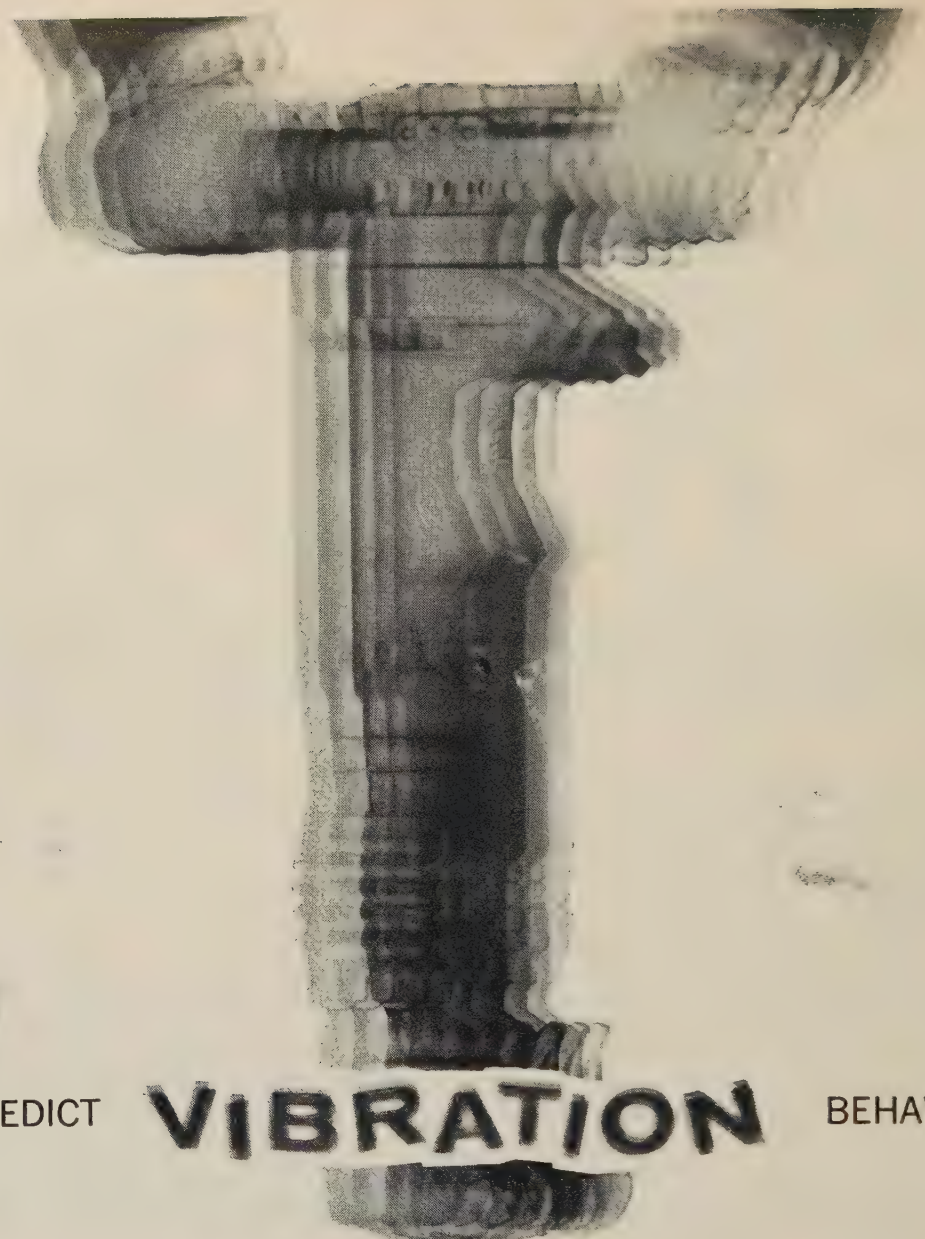

# TO PREDICT VIBRATION BEHAVIOR

. . . rely on the **dynamic analysis** capabilities of Allied Research.

Considerable accomplishments in vibration research and engineering assure reliable prediction of the shock and behavior of complex systems and sub-assemblies — *before* model construction is undertaken. Dynamic analysis pinpoints potential problems in the design stage. Necessary design modifications can then be made before the prototype is built — at substantial savings in time and money.

At Allied Research, dynamic analysis considers every facet of the system or assembly to be produced. This includes an examination of structural characteristics, studies covering the nature of vibration inputs, determination of resonant frequencies under every operation, and prediction of vibratory stresses and the system's susceptibility to fatigue from repeated accelerations. Analytic techniques and evaluations of dynamic models enable Allied Research engineers and designers to effect prompt detection and correction of trouble spots.

Investigate Allied Research's broad capabilities in vibration research and development — analysis, design, testing and equipment manufacturing. Write today for advice and assistance on specific problem areas.

*Allied Research offers immediate key career opportunities in 10 technological fields to scientists and engineers. For full information, forward your resume in complete confidence. A booklet describing Allied Research facilities and capabilities is also available on request.*

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A **BOEING** SUBSIDIARY

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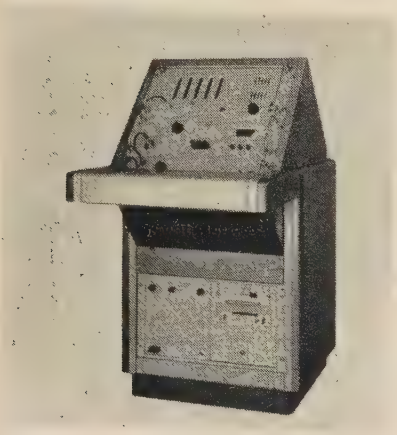
### SUBMINIATURE PROBE for in-line uses

This subminiature probe is designed for in-line use to provide quick make-and-break connections in conjunction with a matching jack or test point. The probe has .040 inch diameter heavily gold-flashed probe on each end of a straight Teflon body and mates with most of the "press-Fit" receptacles taking a .040-in. probe, says **Sealectro Corp., Dept. S/A, 139 Hoyt St., Mamaroneck, N. Y.** As in in-line or hanging type connector, it is not primarily designed for "Press-Fit" installation.

Write in No. 290 on Reader Service Card

### MEASURING SET gives go-no-go indication



Model DY-5344 go-no-go measuring Set is a simplified, complete testing system which measures and compares d-c voltage against preset limits, displays the measured value, and records the test results. The overall accuracy of the measurement and go/no-go comparison is 0.1 per cent of the input range +1 count, says **Hewlett-Packard Co., Dymec Div., Dept. S/A, 395 Page Mill Rd., Palo Alto, Calif.**

Ten manually selected input channels are provided. Input voltage up to 1000 V are handled in four decade ranges.

Write in No. 291 on Reader Service Card

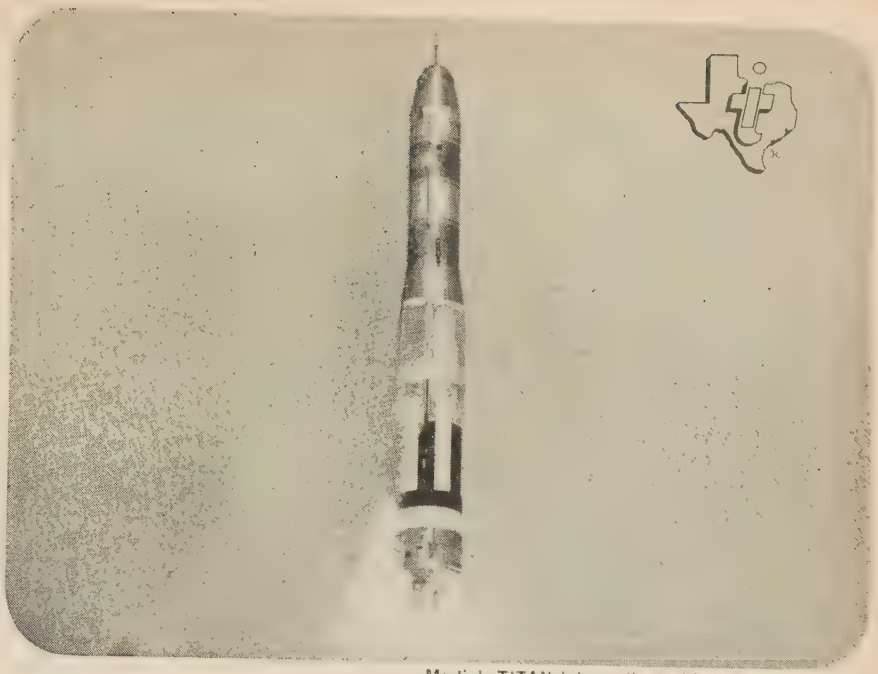
### IN-LINE VALVE is compact

This compact ½ inch in-line valve has a flow coefficient of 7.5, as compared with the usual Cv of 4.0 for that size. It is rated for 300 PSI maximum pressure at 180 deg F., according to **George W. Dahl Co., Inc., Dept. S/A, 86 Tupelo St., Bristol, R. I.** It is 2¾ inch in diameter and 3½ inch in length including hexagonal, screwed connections.

A feature is said to be few parts and the ease with which the plug can be reversed in the field without extra parts.

Write in No. 292 on Reader Service Card

*more on page 231*



Martin's TITAN Intercontinental Ballistic Missile

**TI PROGRAMMERS IN MISSILE SYSTEMS**

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SEMICONDUCTOR-COMPONENTS DIVISION

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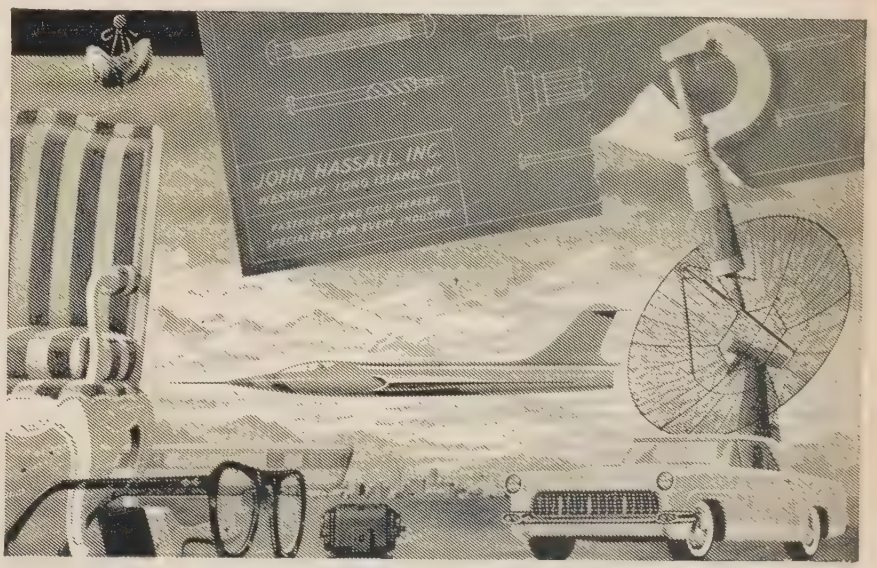

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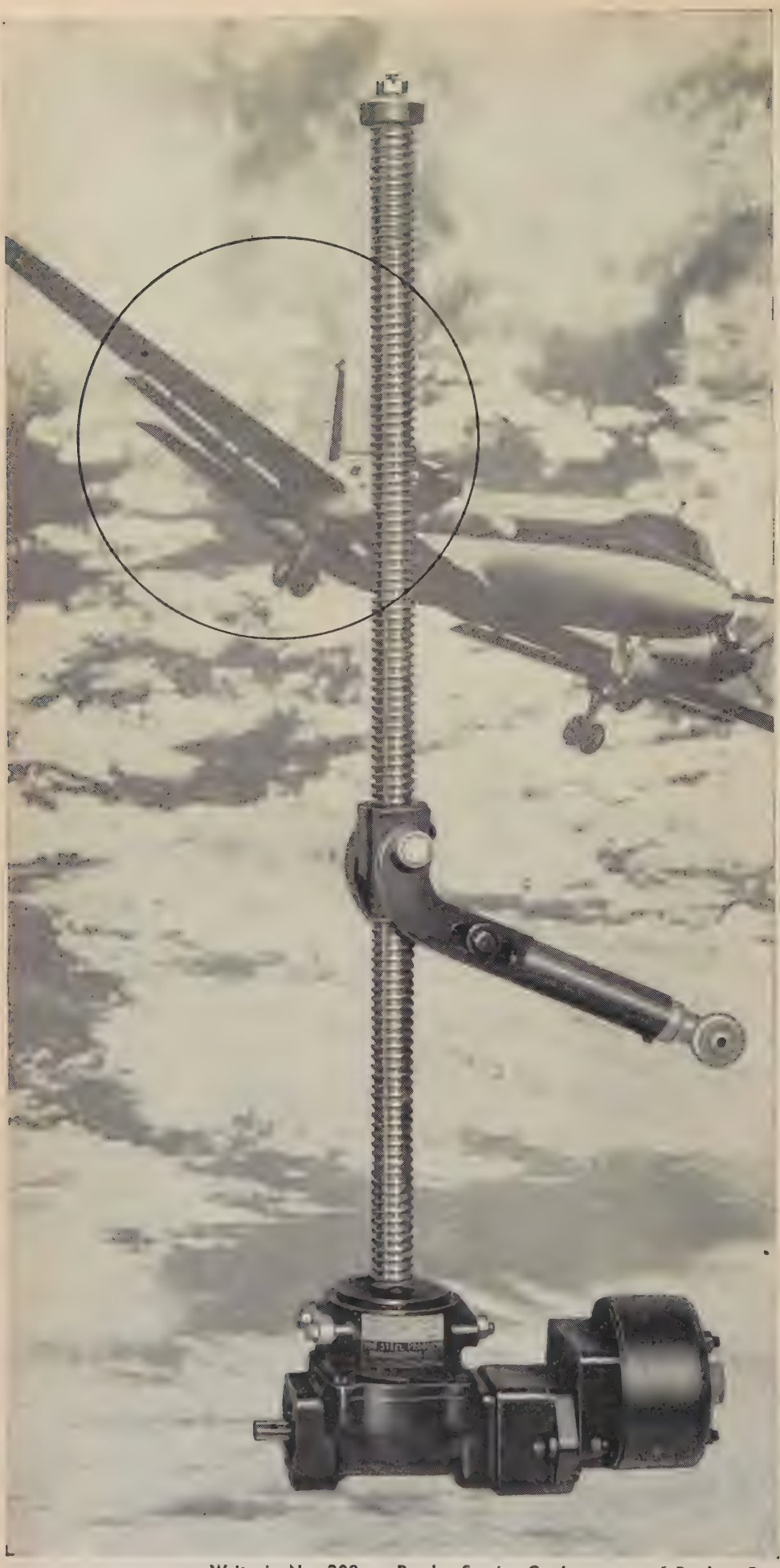

# Grumman Gulfstream

**newest business aircraft equipped with Kelsey-Hayes wing-flap actuators**

This new twin turbo-prop business airplane carries up to 12 passengers in pressurized comfort well above 30,000 ft. and at airspeeds exceeding 350 mph.

Capable of operating from short runway airports, Gulfstream gets its wing flap action from a hydro-mechanical actuation system designed and produced by our SPECO Division in Springfield, Ohio.

SPECO, supplier to the aircraft industry for over 40 years, also produces helicopter transmissions, lightweight special hoists, precision radar antenna mounts, precision gears and gear assemblies for the aerospace industries. Kelsey-Hayes Company, Detroit 32, Michigan.

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### POWER TRANSISTOR meets military specifications

Type 2 N297A germanium PNP power transistor is designed to meet stringent militiary mechanical, environmental, and electrical tests. The units meet Signal Corp specification MIL-T-19500A/36, says **Motorola Inc., Semiconductor Products Div., Dept. S/A, 505 E. McDowell Rd., Phoenix, Ariz.**

Operating temperature range is from —65 deg C to +95 deg C.

Write in No. 293 on Reader Service Card

### SAMPLING SWITCHES feature high-speed scanning

A series of multi-pole sampling switches with exceptional characteristics, the SCANALOG series, is available for high speed scanning of high- and low-level analog voltages and currents. The interlocking modules allow from 24 to 90 contacts in one to 6 poles, says **Fifth Dimension Inc., Dept. S/A, No. Ewing St., Princeton, N. J.**

Multi-contact wipers designed for low-level signal sampling are mounted on the output shaft which, in turn, is mounted in precision ball bearings.

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### METAL SEAL is heat resistant

For applications to al types of valves that involve critical and varying degrees of pressure, flow and temperature, a seal assembly has been specifically tested as a pilot-operated shutoff valve, with 10,000 psi nitrogen and, in different sizes, as a check valve used with various media like gases, hydraulic oils, fuels, ammonium nitrate and methyl ethyl ketone, at temperatures varying from —20 deg to +650 deg F, says **Hydraulic Mechanisms, Inc., Dept. S/A, 1047 61st St., Brooklyn 19, N.Y.** It is based on the principle of two metal surfaces coming into contact on a single line plane.

The members are said to be so designed that small pressures will deflect any irregularity and give a complete seal between the seat and poppet.

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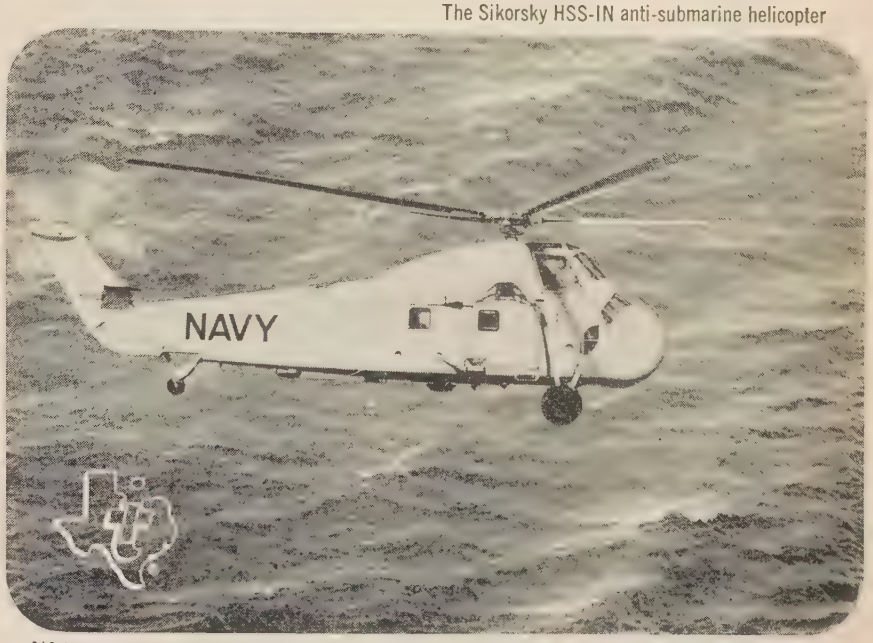
*more on next page*

APPARATUS DIVISION

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE • DALLAS 9, TEXAS

# TI SONAR IN ASW SYSTEMS

The Sikorsky HSS-IN anti-submarine helicopter

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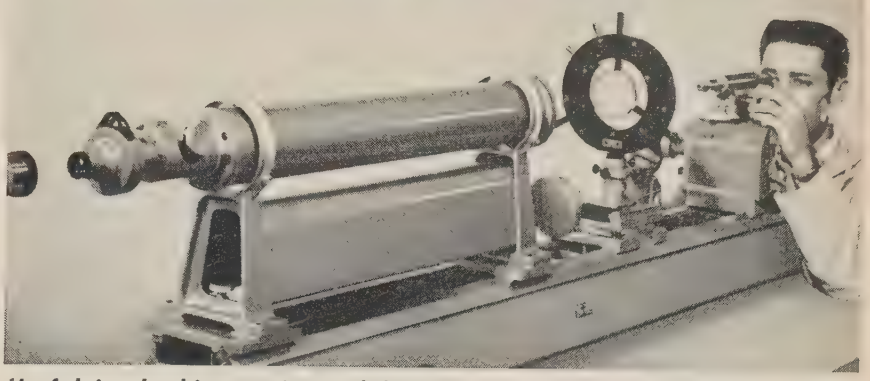
## Gaertner Precision Optical Bench Assembly



*Useful in checking optics and for experimental instrumentation setups*

The Precision Optical Bench is a versatile measuring instrument consisting of a lathe-bed-type base, light source, collimator with interchangeable filters and targets, nodal slide and microscope with three-dimensional adjustment. Focal lengths, resolving power and the various aberrations of optical parts and systems can be measured.

The several components can be used independently for special test setups, mock-ups and experimental instrumentation — providing linear and angular motions and measurements, alignment and stable support.

Double and single rod benches and a large selection of carriages, holders and supports provide a complete selection from which to choose.

Gaertner offers a wide range of optical and measuring instruments, including special modifications, design and manufacture of special instruments and optical systems, and manufacture of subassemblies and instruments from customer sketches and drawings.

*Send for bulletin 156-59*

**Gaertner** SCIENTIFIC CORPORATION
1270 Wrightwood Ave.
Chicago 14, BU 1-5335

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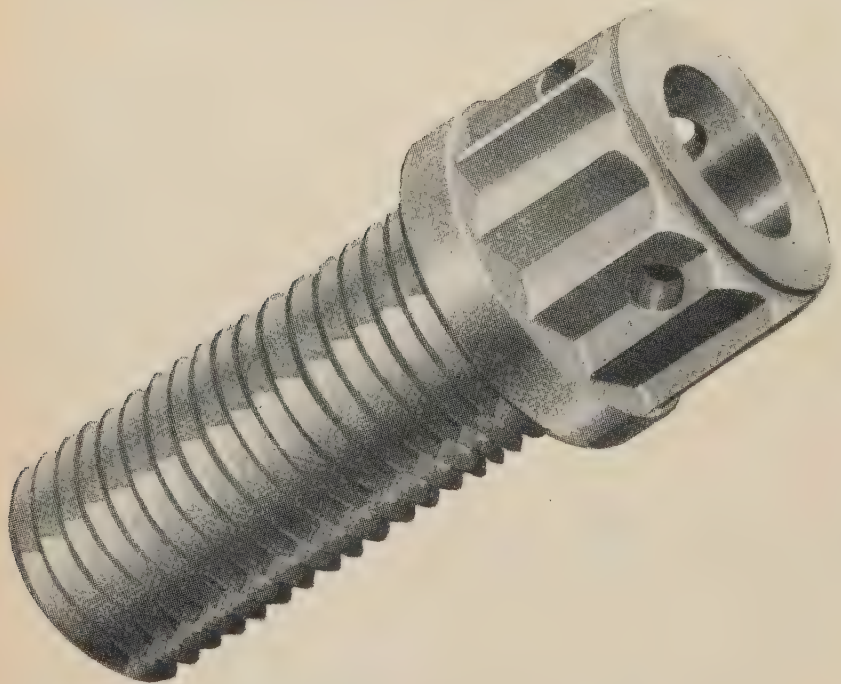
Men who know and specify special fasteners depend on this familar symbol . . . CP . . . the famous Chandler hallmark for precision and reliability in fasteners. It's your guarantee that each fastener meets the rigorous materials and performance tests required by industrial and military standards. Before placing your next order . . .

**check with chandler . . .**



**for precision cap screws!**

Produced to your specifications . . . delivered to your requirements!

*Send for your Chandler catalog today.*

CHANDLER PRODUCTS CORPORATION • 1493 Chardon Road • Cleveland 17, Ohio

Write in No. 211 on Reader Service Card at start of Product Preview Section



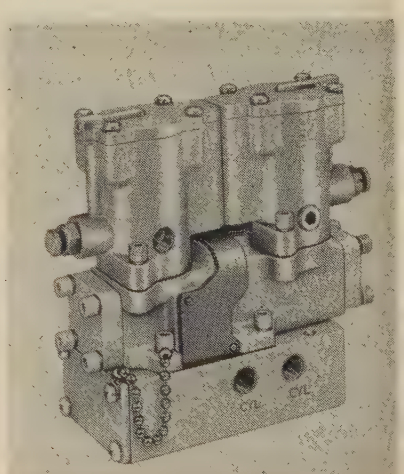

## *METALS for tubing*

Columbium, tantalum and vanadium—metals from the reactive group—are available commercially in small tubing form. Present and potential applications for columbium tubing are in the nuclear field, according to **Superior Tube Co., Dept. S/A, 1902 Germantown Ave., Norristown, Pa.** Its low neutron absorption makes it suitable for fuel element cladding, and its corrosion resistance to water, liquid metals and molten salts makes it useful for piping for reactor coolants.

Outstanding property of tantalum tubing is its corrosion resistance, particularly to acids. Vanadium has a density approximately two-thirds that of columbium and a strength to weight ratio approximately equal to that of type 304 stainless steel, it is said.

Write in No. 296 on Reader Service Card

## *CONTROL VALVES are plug-in types*

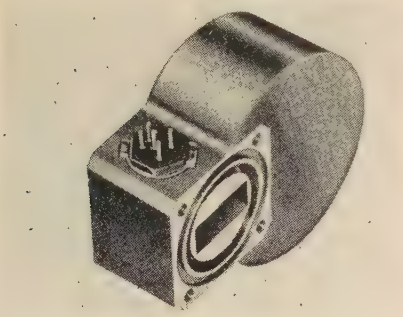


Electrical, pneumatic or fluid connections are made automatically as the body, sub-base and pilot of this plug-in type control valve are bolted into place, according to **Valvair Corp., Dept. S/A, 454 Morgan Ave., Akron 11, O.** The ¼-in Speed King features one-piece construction of solenoid housing, and aluminum body and sub-base.

The unit is offered in single and double solenoid types, for sub-base or multiple manifold mounting. Service rating for the four-way valve is 30 to 200 psi, and the unit is available with solenoid coils for ac or dc, any voltage. The coils are encapsulated in molded resin and are guaranteed against burn-out for the life of the valve. Compact size, very fast operating response, and low installation and manufacturing costs are among the advantages, and service life is reported to exceed 25 million cycles.

Write in No. 297 on Reader Service Card

### FERRITE SHUTTER SWITCH is lightweight



Model W574-1A-1 is a Bilateral H-Plane Ferrite Switch readily adaptable for use in monopulse and doppler radar systems, surveillance and fire control systems. There are no moving parts and the switch may be used as a shutter or switch element, says **Kearfott Co. Inc., Microwave Div., Dept. S/A, 14844 Oxnard St., Van Nuys, Calif.**

Ambient temperature is from −85 deg to +105 deg C. Weight is 5 oz and dimensions are 2⅜ x 1⁵⁄₁₆ x 1 in.

Write in No. 298 on Reader Service Card

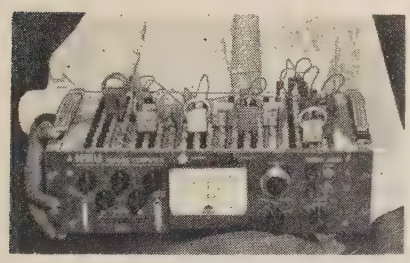
### GEAR MOTOR is miniaturized

A one-hp gear motor with a diameter of under 2½ in has been announced by **Western Gear Corp., Dept. S/A, 132 W. Colorado Blvd., Pasadena, Calif.** Output speed of the Model 70DC1RTO can be varied in accordance with requirements, and one unit has an output shaft speed of 7000 rpm.

The motor requires 28 V dc at 65 amps.

Write in No. 299 on Reader Service Card

### ANALOG COMPUTER weighs 23 lb



Model 3500, 10-amplifier analog computer can be used to study almost any physical system, that can be described by linear differential equations. It will solve up to a seventh order differential equation or a ninth degree Laplace transform, says **Donner Scientific Co., Dept. S/A, Concord, Calif.**

Beside its 10-amplifier channels, the complete computer includes a null voltmeter, five pots for coefficients or initial conditions, and all power supplies and control circuitry.

Write in No. 300 on Reader Service Card

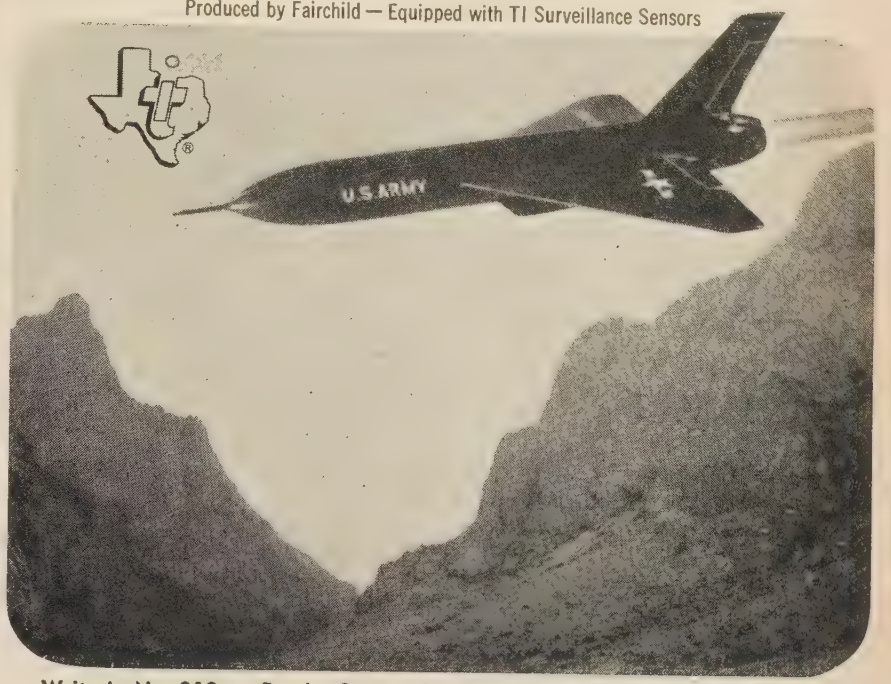
*more on page 235*


APPARATUS DIVISION

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE • DALLAS 9, TEXAS

**TI IN SURVEILLANCE SYSTEMS**

U. S. Army Signal Corps AN/USD-5 Combat Reconnaissance Drone
Produced by Fairchild — Equipped with TI Surveillance Sensors




Write in No. 212 on Reader Service Card at start of Product Preview Section

**ALINA SERIES "W" BORE GAGES**

**Range from .160" to 12"**

Alina bore gages are extremely sensitive and designed for trouble-free operation.
The three point centralization system locates the gage in the hole quickly and accurately.
Alina bore gages will swiftly reveal taper, bell mouth, out of round, and other dimensional variations.

A push-button retracts the movable anvil for easy non-scratching insertion into the workpiece. This feature also saves wear on the anvils.

Each gage is equipped with tungsten carbide contact points for lasting on the job accuracy. (except model WO-1).

Bore gages with measuring depths up to 40" delivered on special order.
Model WO-1 available with measuring heads down to .160".

Furnished as a set complete with depth adjustment stops and fitted wooden case.

WRITE FOR ILLUSTRATED LITERATURE

**ALINA CORPORATION**

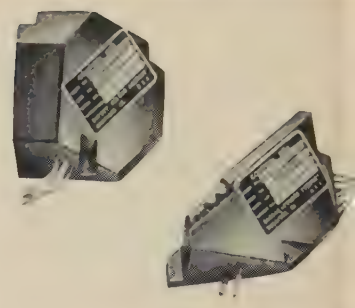
122 East Second Street, Mineola, Long Island, New York

Write in No. 213 on Reader Service Card at start of Product Preview Section

# how Barber-Colman engineers meet critical tolerance and envelope challenge of Titan temperature control project

*Assignment* to Barber-Colman Company from Air Force TITAN associate contractor, AC Spark Plug, Milwaukee: Take one part of the Air Force TITAN guidance platform and develop a complete temperature control system that will fit into the odd-shaped, very limited space available. Hold temperature to the exceptionally close tolerances specified. *Result:* A precision Barber-Colman temperature control system incorporating an ingeniously formed set of compact control boxes and sensing element (right) which control temperature of the internal structure to within a few hundredths of one degree. Unusual assignments like this are the kind of challenge that Barber-Colman people like to accept. For help with your temperature control problems consult the Barber-Colman engineering sales office nearest you: Baltimore, Boston, Fort Worth, Los Angeles, Montreal, New York, Rockford, Seattle.

**FORM-FITTING TEMPERATURE CONTROL BOXES FIT SMALL, IRREGULAR SPACE**



Related control boxes and sensing elemen for Air Force TITAN guidance platform temp erature control application.

THE MARK OF QUALITY

BARBER COLMAN

## BARBER-COLMAN COMPANY

DEPT. F, 1423 ROCK STREET, ROCKFORD, ILLINOIS

*AIRCRAFT AND MISSILE PRODUCTS: AIR VALVES, ELECTROMECHANICAL ACTUATORS, TEMPERATURE CONTROL SYSTEMS, POSITIONING SYSTEMS, TRANSDUCERS AND THERMOSTATS, SPECIAL GROUND TEST EQUIPMENT*

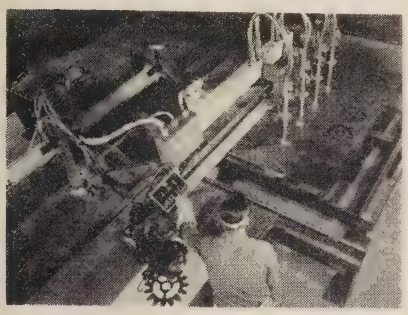
**Write in No. 214 on Reader Service Card at start of Product Preview Section**

### FLOW METER uses sonic nozzles

This sonic flow nozzle, operating on the critical flow principle, measures the mass rate of air flow with an accuracy tolerance of less than 2.0 per cent under normal test conditions. It is recommended for general test laboratory use in calibrating other meters or obtaining pressure drop and cooling characteristic data on electronic packages and air conditioning components, says **Flow-Dyne Engineering, Dept. S/A, P. O. Box 13141, Fort Worth 18, Tex.** Set is made into one-inch "AN" unions and designed to cover the air-flow range of .05 to 20.0 pounds per minute (0.66 to 267 SCFM).

Write in No. 301 on Reader Service Card

### CUTTING MACHINE in pantograph design



This eight-foot cutting machine of pantograph design, first of its kind, is for medium duty shape cutting. Equipped to carry a maximum of four motorized torches for use with acetylene, propane or natural gas, it can do straight line cutting anywhere within a rectangle bounded by a 96 in. width and an indefinite length determined by the number of rails and tracks used, according to **Air Reduction Co., Dept. S/A, 150 E. 42 St., New York 17, N. Y.**

Principal innovation is said to be its centralized operator control.

Write in No. 302 on Reader Service Card

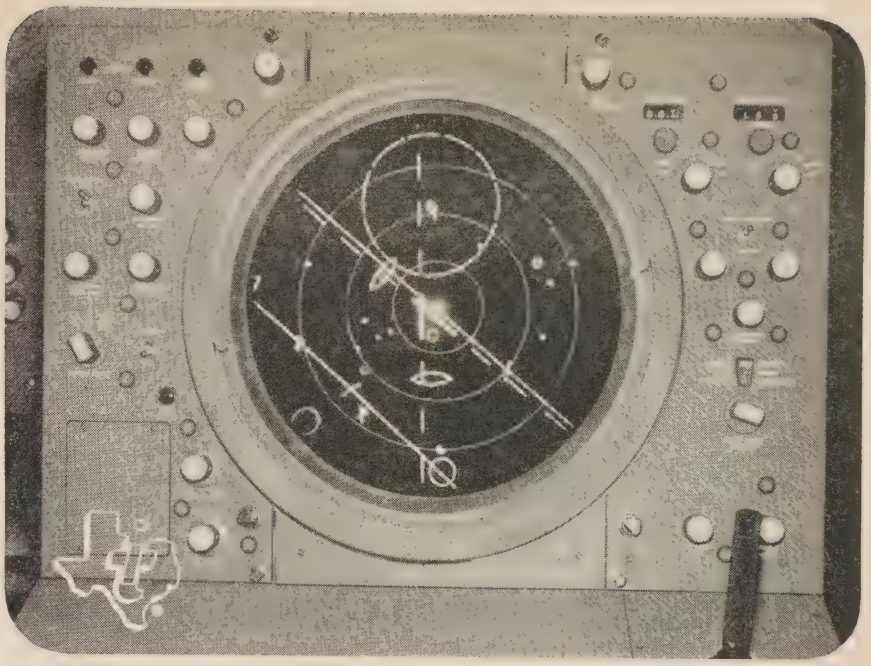
### TANTALUM-TUNGSTEN in alloy sheets

Commercial availability of high purity 90 per cent tantalum-10 per cent tungsten alloy sheet in widths up to 8 inches and thicknesses from 0.010 inch to heavy plate has been announced by the **National Research Corp., Metals Div., Dept. S/A, 70 Memorial Drive, Cambridge 42, Mass.** High temperature strength combined with fabrication properties make it suitable for rocket engines, missile structures, electronic components and other applications where temperatures exceed 3000 deg F.

The alloys previously have been supplied by NRC in the form of vacuum cast ingots and forging billets.

Write in No. 303 on Reader Service Card

*more on next page*

Ground clutter is eliminated by TI moving target indicator shown with video map at 20-mile range.

**TI IN HEAVY RADAR SYSTEMS**

APPARATUS DIVISION

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE • DALLAS 9, TEXAS

Write in No. 215 on Reader Service Card at start of Product Preview Section

**HUGHES AIRCRAFT COMPANY USES SEL-REX BRIGHT GOLD PROCESS**

*to plate guided missile components*

*Magnet holds over 100 Gold Plated miniature missile parts.*

Critical guided missile manufacturing requires the best materials. That's why BRIGHT GOLD and other SEL-REX Precious Metals Processes are specified for this work.

We actually improve the metallurgical properties of precious metals electroplate. BRIGHT GOLD, for example, gives six times more protection with ¼ *the amount of Gold**, as compared with conventional 24K Gold plate.

**Technical data on request.*

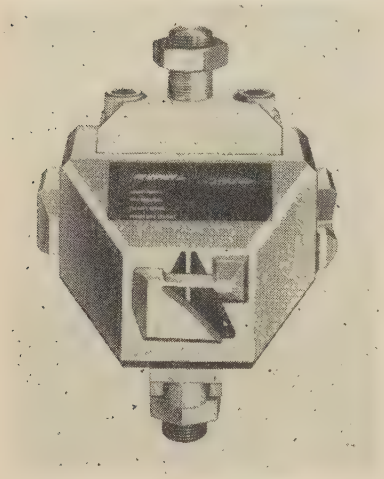
Sel-Rex

**SEL-REX CORPORATION**
NUTLEY 10, NEW JERSEY

*The world's largest selling precious metal electroplating processes.*

Write in No. 216 on Reader Service Card at start of Product Preview Section

### *FLEXURE PIVOT is universal, small*



This small-size flexure pivot is for high-precision calibrating systems and thrust stands, rocket motor test programs, precision weighing systems, fatigue machines, and quality measuring systems. Units are supplied as completely universal pivots, two-direction, or single-direction, says **Aeroscience, Inc., Dept. S/A, 3155 N. Rosemead Blvd., Rosemead, Calif.** Side flexures provide stability for reacting side and torsional loads.

Size is 1.45 in cube. A 200,000 lb capacity unit occupies a space less than 14 cubic inches. It is supplied in capacities from 0 to 1,500,000 lbs.

Write in No. 304 on Reader Service Card

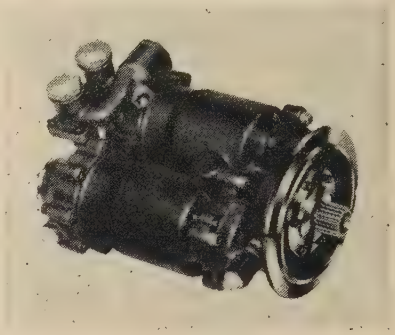
### *TWO-AXIS GYRO for missile guidance*

This two-axis free gyro measures 4 inches by 2.75 inches diameter and weighs less than 2½ pounds. It is equipped with a synchro-type pick-off on the outer gimbal, says **Giannini Controls Corp., Dept. S/A, 918 E. Green St., Pasadena, Calif.** The unit will withstand 40 g acceleration and shock, and will operate over a temperature range of —54 to +71 deg C.

Other critical specifications include: Range, outer gimbal 360 deg, inner gimbal ±80 deg from the caged (0 deg) position; drift, static, 0.7 deg per minute average, Scorsby, 0.7 deg per minute average; vibration, 20-30 cps (5±1g), 300-200 cps (10±1g).

Write in No. 305 on Reader Service Card

### *HYDRAULIC PUMP for up to 4000 psi*



This piston pump maintains hydraulic system pressures to 4000 psi full flow with fluid temperatures to 550 deg F. The dual pump element incorporates two independent pumping elements within a single body, both driven by a common shaft, says **Borg-Warner Corp., Pesco Products Div., Dept. S/A, 24700 N. Miles Blvd., Bedford, Ohio.**

Positive protection against failure is afforded by the twin pump elements, each able to support full system pressure.

Write in No. 306 on Reader Service Card


# WHITTAKER ACCELEROMETERS

*. . . a significant breakthrough in design simplicity and performance reliability!*

Whittaker Accelerometers are the result of advanced design concepts, developed in the laboratories of one of the World's leading precision instrument manufacturers.

**Here are some of the valuable features of Whittaker Accelerometers:**

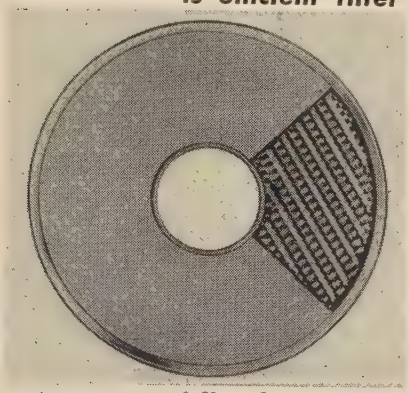
• Air-Damped • Few parts • Low cost • High reliability • Available with linear differential transformers or potentiometer outputs • Dynamic performance values comparable to more sophisticated instruments • Can be operated at temperatures in excess of 300°F. • Wide range of G values available • Performance closely approximates ideal second order system response.

**WHITTAKER GYRO has produced more than 400,000 Guidance Instruments, many of them for major missile programs. All WG Products are the result of:**

- Better Design concepts
- Complete value analysis
- Integrity testing programs
- Quality control that is second to none
- Constant R&D for product improvement

ADVANCED CONCEPTS NOW IN THE PLANNING STATE AT WHITTAKER GYRO PRESENT UNUSUAL AND CHALLENGING OPPORTUNITIES FOR QUALIFIED ENGINEERS. WHY NOT INQUIRE NOW?

### METAL DISC is efficient filter



A porous metal filter disc consisting of two cylindrical sheets of highly ductile fibrous stainless steel has been designed for relatively low flow and high contaminant/or product collection, says **Purolator Products, Inc., Dept. S/A, Rahway, N.J.** High permeability, a ten-micron pore size, and an effective filtering area of about one sq ft are featured.

The discs are useful over wide temperature ranges at differential pressures to over 200 psi, and they are impervious to most concentrations of nitric acid. In addition to their usefulness as complete filter systems, the discs may serve as replacements for multiple-stacked disc units now in the field.

Write in No. 307 on Reader Service Card

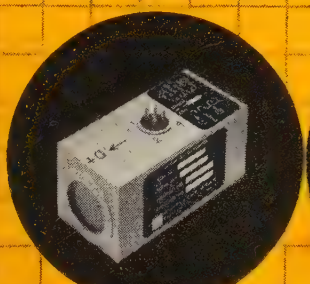
### TIME DELAY RELAY isolated switching

A relay having a combination of features to meet airborne and missile application requirements include hermetic sealing, instantaneous resetting, isolated load contacts, voltage and ambient temperature compensations is announced by **Curtiss-Wright, Dept. S/A, 620 Passaic Ave. West Caldwell, N. J.** The relay is said to reset the instant it is deenergized, providing the same time delay period for each succeeding cyclex through use of a special thermal element in conjunction with a pair of magnetic relays.

Voltage compensation for 22 to 32 volts dc. Temperature compensation range is —65 deg C to +125 deg C. Power drain less than 3 watts after the timing period: 10 during timing. Contact rating 2 amps at 28 volts dc resistive load.

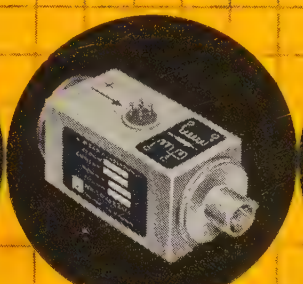
Write in No. 308 on Reader Service Card

*more on next page*

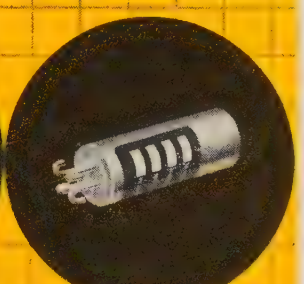
LINEAR ACCELEROMETER TYPE Z-125

AC Linear Transducer
(Size: 1 1/16" x 3 3/16")
Request Product Brochure LA 1.25



LINEAR ACCELEROMETER TYPE Z-130

Potentiometer Output
(Size: 1 3/8" x 3 1/4")
Request Product Data Z-130



SUB-MINIATURE ACCELEROMETER TYPE Z-140

AC Linear Transducer
(Size: 7/16" dia. x 3/4")
Request Product Data Z-140

For further data, write for Whittaker Gyro Product Brochures by number as indicated under illustrations.

**WHITTAKER GYRO** *Division of*

*16217 Lindbergh Street, Van Nuys, California*
*Phone: TRiangle 3-1950*

WG

**WHITTAKER GYRO**
*"Your Guide to Better Flight Control Systems and Components"*

WG — **WHITTAKER GYRO:** Leading designer and manufacturer of precision gyroscopes, accelerometers guidance and control systems.

WC — **WHITTAKER CONTROLS:** Designs and produces fluid control systems, subsystems and components for military and commercial aircraft and missiles.

DI — **DATA INSTRUMENTS:** Leading designer and producer of data reduction systems, industrial control and ground support equipment.

NI — **NARMCO INDUSTRIES:** Specializing in research and manufacturing in the field of lightweight, high-strength structural components and materials for a variety of Military and Industrial applications.

MA — **MONROVIA AVIATION:** Producers of precision aircraft structural assemblies and portable air conditioning units for ground support.

TSI — **TELECOMPUTING SERVICES, INC.:** Specialists in data processing and data systems engineering.

ES — **ELECTRONIC SYSTEMS:** Specialists in systems management, and in the design and manufacture of complex electronic and nucleonic equipment for Government and industry.

CB — **COOK BATTERIES:** Designers and manufacturers of automatically and manually activated silver zinc batteries for missile applications.

PE — **PHOENIX ENGINEERING:** Manufacturer and assembler of precision machined missile, aircraft and electronic parts.

EC — **ELECTRONIC COMPONENTS:** Designers and producers of micro-miniature relays, sub-miniature ceramic capacitors, magnetic amplifiers, transformers and delay lines.

## TELECOMPUTING CORPORATION

*Los Angeles, California*

Telecomputing Corporation is a unique combination of carefully integrated organizations. It is staffed with scientific talent of rare ability, designed for the purpose of managing entire Space Technology and Weapon System Projects. Telecomputing is developing *advanced concepts* in industrial and military control systems.

**Write in No. 217 on Reader Service Card**

### MICROWAVE SWITCH saves space, weight

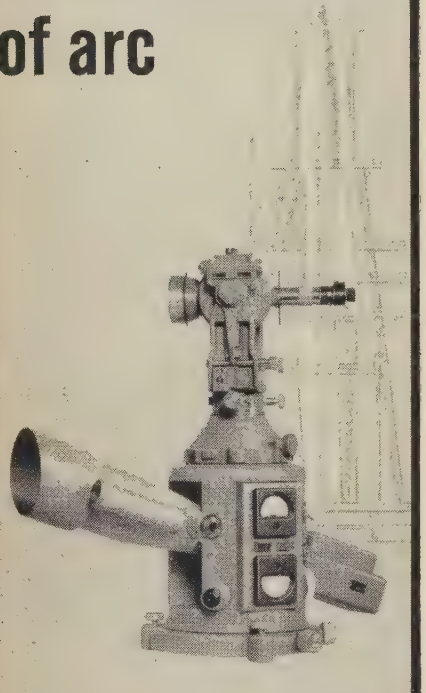
This compact, lightweight X-band microwave switch has a frequency range 8.2 to 12.4 kmc, and provides 40 db of isolation over the entire band. Model X-160R, with 50 db of isolation, also includes an internal relay that permits remote, low current energizing of the actuating solenoid, says **Radar Measurements Corp., Dept. S/A, 190 Duffy Ave., Hicksville, N.Y.** It meets a wide range of application requirements in microwave systems, including the elimination of interference and ground returns in testing several radars at the same location and insuring radar silence while a radar transmitter is in operation.

Measuring less than 6x3 inches and weighing 2 lbs, the switch incorporates interlocks to protect magnetrons during the switching operation and requires no external dropping resistor for the solenoid drive.

Write in No. 309 on Reader Service Card

more on page 240


# Azimuth alignment to one second of arc



J. W. Fecker's new Azimuth Alignment Portable Theodolites give sensitivity and reproducibility to one second of arc!

Model 100's simplified optical autocollimating system provides a single light source with no need for light balance or regulation of power to light source. Phase rather than amplitude measuring systems make the unit insensitive to electrical noise and light variations.

Miniaturized electronic controls are available as an integral part of the instrument or may be remotely located.

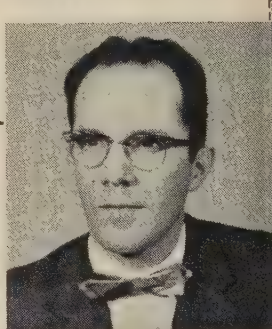
Want to know more about Model 100? Or about equipment designed specifically to meet your needs? Write.

**j. w. fecker**
*Division of American Optical Co.*
6592 Hamilton Ave., Pittsburgh 6, Pa.

Write in No. 218 on Reader Service Card

# "FASTAX EXPOSES CAVITATION DAMAGE of METALS"

**writes W. C. LEITH**
**of DOMINION ENGINEERING COMPANY, LTD.**



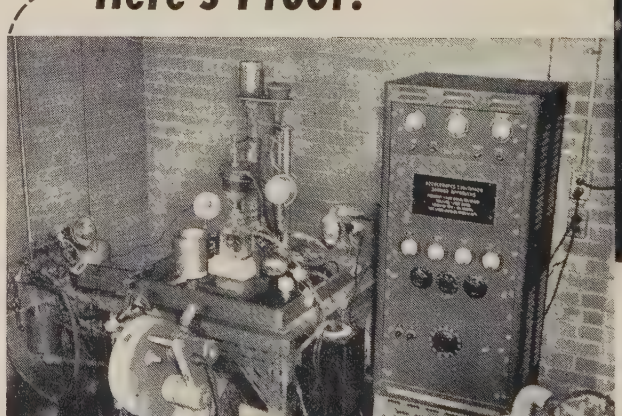
*W. C. Leith winner of the Engineering Institute of Canada (1959) Duggan Prize and Medal for his paper "Cavitation Damage of Metals."*

"A FASTAX camera has been used in our cavitation research program. The model WF-4 at 8,000 frames per second identified the bubble pattern on a test button subjected to accelerated cavitation in distilled water." (Films show cavitation bubble pattern similar to damage pattern).

"The FASTAX camera, providing a time magnification factor of 500 for this work, contributed substantially to the exploration of this somewhat obscure subject."

W. C. Leith

## Here's Proof:



*Bubble pattern on vibrating test button.*

*Accelerated cavitation apparatus with FASTAX camera ready to record results.*

**LET FASTAX HIGH SPEED PHOTOGRAPHY HELP SOLVE YOUR ENGINEERING ANALYSIS PROBLEMS**

FOR THE FINEST IN PHOTOGRAPHY THE WORLD OVER • IT'S WOLLENSAK •

**WRITE** for more detailed information and literature.

**WOLLENSAK**
OPTICAL COMPANY • ROCHESTER 21, N. Y.

Write in No. 219 on Reader Service Card at start of Product Preview Section

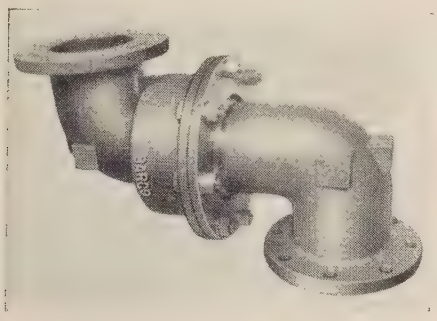
3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS

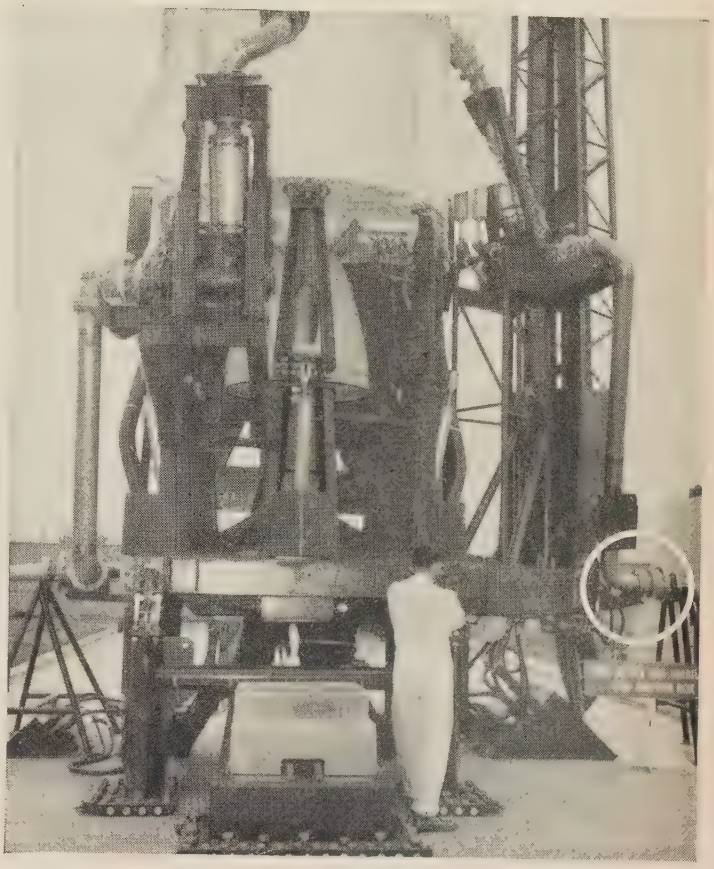
# Liners of KEL-F® BRAND PLASTIC for ball joints... FUEL-PROOF and WEAR-RESISTANT

Flexible ball joints (see photo below) manufactured by the Barco Manufacturing Company of Barrington, Illinois, provide for swiveling or angular flexing and thermal contraction in fueling lines for today's rocket powered ballistic missiles. Like the pipeline, these joints must withstand the corrosive action of such highly volatile fuels as LOX and JP fuels 3, 4 and 5. A sealing and lining agent was required that would make the joints impervious to the corrosive action of these fuels.

Barco Manufacturing Company found the answer. KEL-F Brand Plastic was supplied to them in sheet form. Barco, in turn, die-cut the KEL-F plastic into the required shapes for use as liners and sealers in the swivel mechanism of the ball joints.



Why KEL-F Plastic? Because the corrosive action of high energy rocket fuels can't faze it. Because cold can't shatter it . . . heat can't melt it. It's performance proved. KEL-F Plastic withstands a temperature range of −320° F. to +425° F. In addition, its excellent flexibility and high impact and compressive strength provide an extra safety measure to the joints to insure against dangerous blow-outs and costly leakage.



KEL-F Plastic is ideally suited for many uses in the field of rockets, missiles and aircraft because it is chemically inert, thermally stable, has high impact, tensile and compressive strength plus zero moisture absorption and easy moldability. Among its many uses: O-rings, LOX lip seals, valve diaphragms, flow meters and fuel bladders.

For complete performance characteristics, write today specifying area of interest to: 3M Chemical Division, Dept. KAO-60, St. Paul 6, Minnesota.

"KEL-F" is a Reg. T. M. of 3M Co.

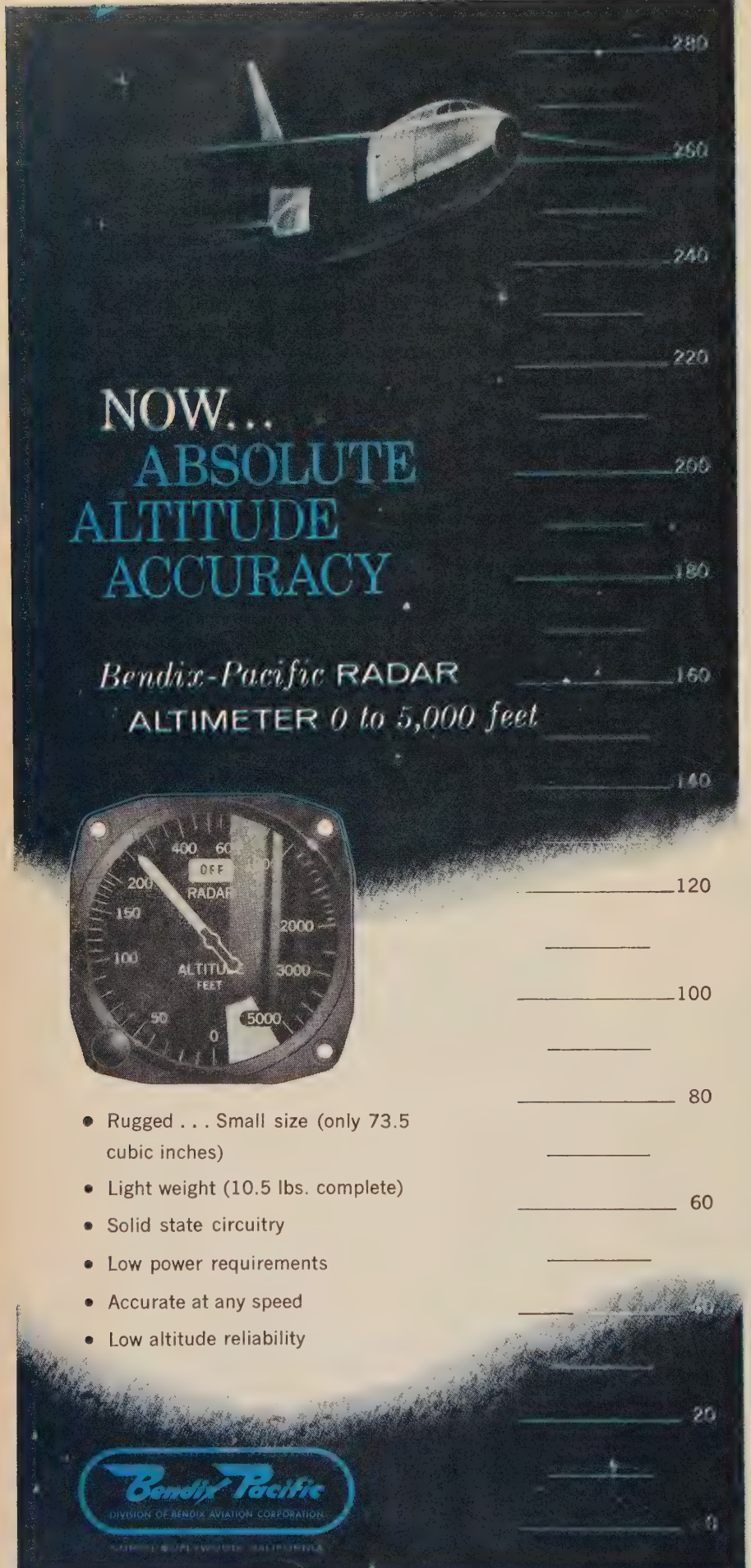
CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Write in No. 220 on Reader Service Card at start of Product Preview Section



Write in No. 221 on Reader Service Card at start of Product Preview Section



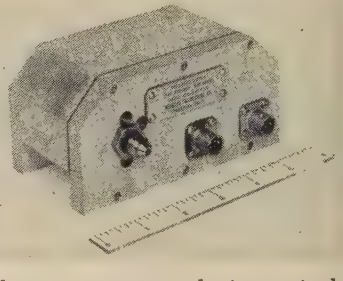

## RECORDER INK prevents data loss

A new ink has been compounded for ball-pen application to recording instruments to prevent data loss as a result of clogging, skipping, missing, or smearing, according to **Formulabs, Inc., Dept. S/A, Escondido, Calif.** Advantages include instant starting after long idle periods, operation at high ambient temperatures, and excellent photo-copying characteristics.

The ball-pen ink has been successfully used in a missile test data recorder that writes up to 60 fpm.

Write in No. 310 on Reader Service Card

## PRESSURE SWITCH in compact package



This pressure switch is a single lightweight package combining transducer, solid-state carrier oscillator, ring demodulator, and switching transistor. DC input voltage is converted to ac for excitation of a variable-reluctance magnetic circuit, says **Wiancko Engineering Co., Dept. S/A, 255 N. Halstead, Pasadena, Calif.** Absence of mechanical contacts permits no chatter, or shift in the electrical output due to vibration.

Range is 10 to 3000 psig; maximum working pressure, 200 per cent of nominal switch pressure; accuracy, ±1.5 per cent of setting; switch pressure adjustment, ±16 per cent of nominal switch pressure, adjustable.

Write in No. 311 on Reader Service Card

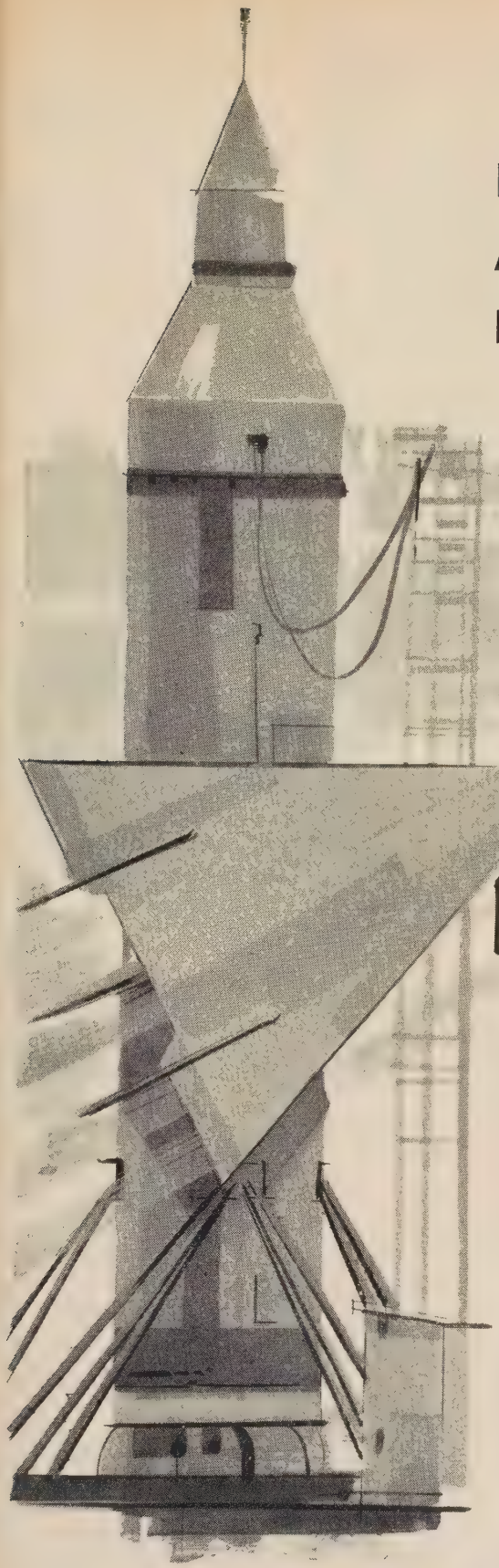
## CONTROL VALVES for submarines

Automatic control valves, designed to meet exceptionally precise missile launching requirements for Polaris-firing submarines, operates as integral parts of the missile launch system. They are of two distinct types, according to **Garrett Corp., Dept. S/A, 9225 Aviation Blvd., Los Angeles 45, Calif.**

One type is a single stage pressure regulator that provides air at constant, relatively low pressure from a high pressure storage system; the other, pressure reducing valve regulates compressed air to control the rapid movement of large volumes of ballast water to trim the submarine when a missile is fired.

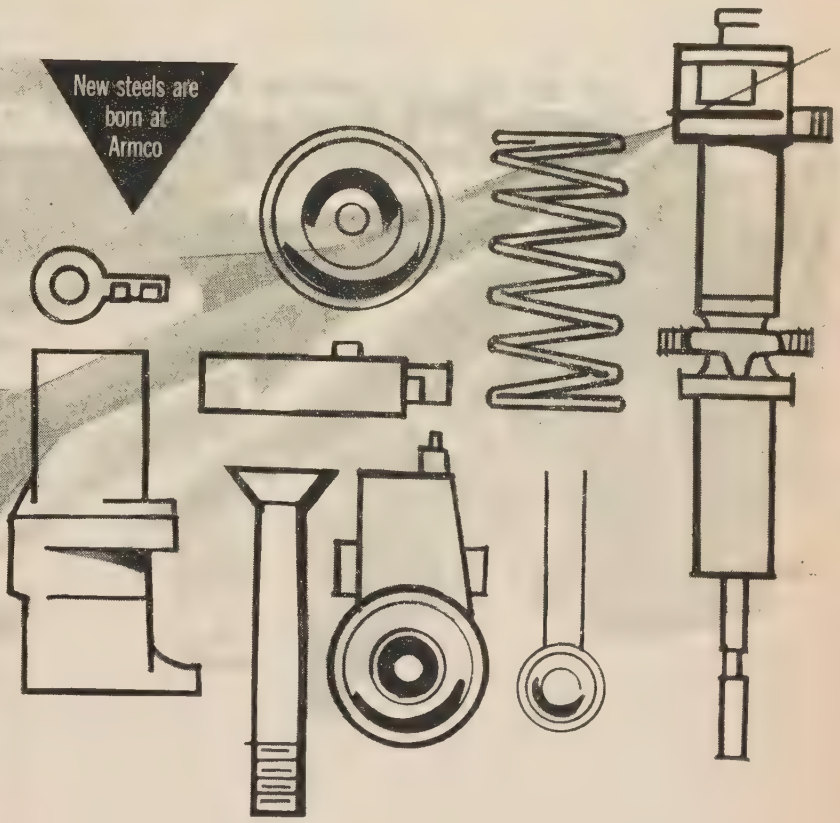
Write in No. 312 on Reader Service Card

more on page 242



FOR THOSE LITTLE PARTS WITH BIG JOBS

# ARMCO 17-4 PH, 17-7 PH, PH 15-7 Mo STAINLESS STEELS




For bolts, rivets, shafts, gears, springs, valves, hydraulic units, guidance components, and the thousand and one vital parts of aircraft and missiles that must operate with maximum reliability, Armco's Precipitation-Hardening Stainless Steels offer:

**Unusually high strength weight ratios up to 1000 F**
**Good corrosion resistance**
**Excellent fabricating properties**
**Availability in practically all commercial forms**

For complete information on these special Armco Stainless Steels that are providing design and production advantages in both missile and aircraft manufacture, write Armco Steel Corporation, 2200 Curtis Street, Middletown, Ohio.

Stainless Steel

# ARMCO STEEL

ARMCO

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

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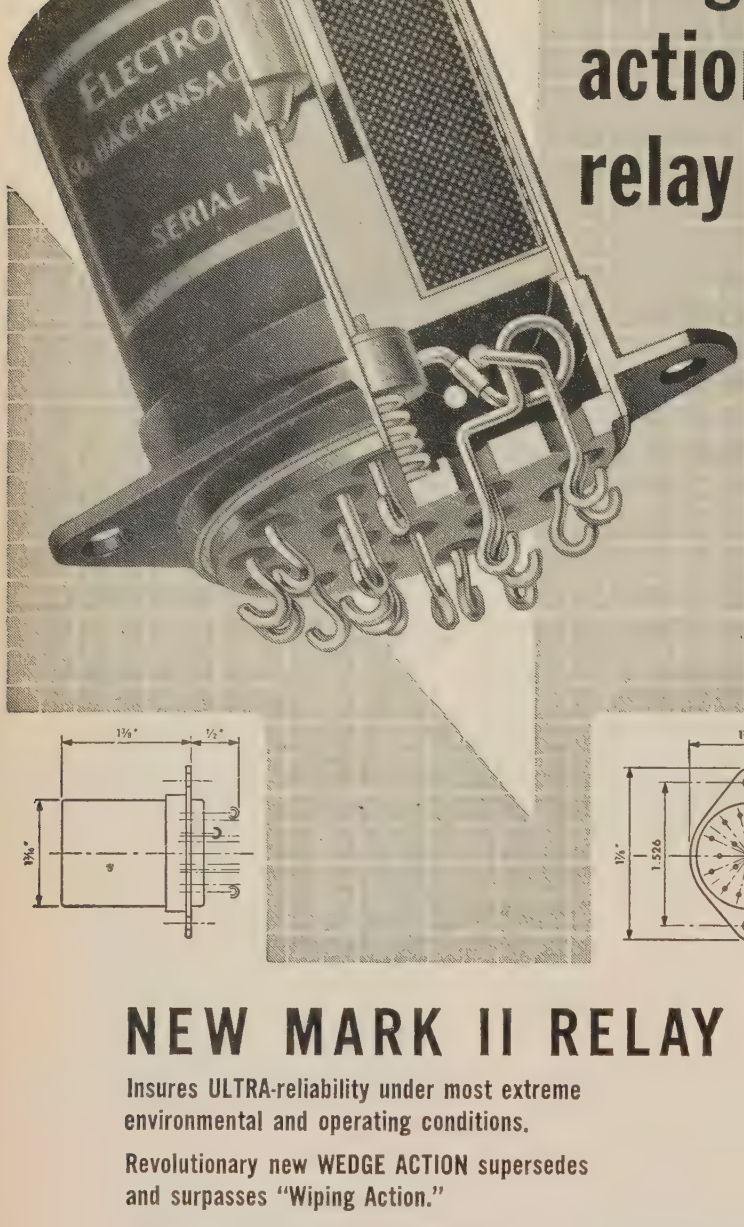
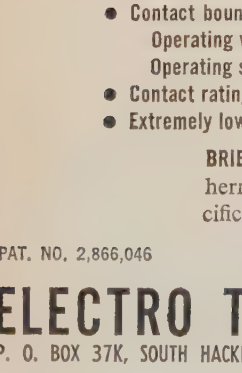
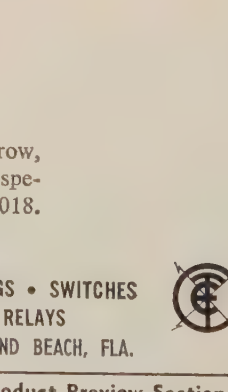
# The First...

# wedge action relay







## NEW MARK II RELAY

**Insures ULTRA-reliability under most extreme environmental and operating conditions.**

**Revolutionary new WEDGE ACTION supersedes and surpasses "Wiping Action."**

**Contact pressure constantly increases during over-travel.**

- Temperature range: – 65°C to 200°C.
- Contact bounce: NONE.
  Operating vibration: 5 to 2,000 cps, 30 G's.
  Operating shock: 100 G.
- Contact rating: dry circuit to 2 amps.
- Extremely low contact resistance.

**BRIEF DESCRIPTION:** Six pole, double-throw, hermetically sealed. Meets and exceeds specifications MIL-R-5757C and MIL-R-25018.

PAT. NO. 2,866,046

*Write for illustrated literature.*

**ELECTRO TEC CORP.**

SLIP RINGS • SWITCHES
RELAYS

P. O. BOX 37K, SOUTH HACKENSACK, N. J. BLACKSBURG, VA., ORMOND BEACH, FLA.

Write in No. 223 on Reader Service Card at start of Product Preview Section



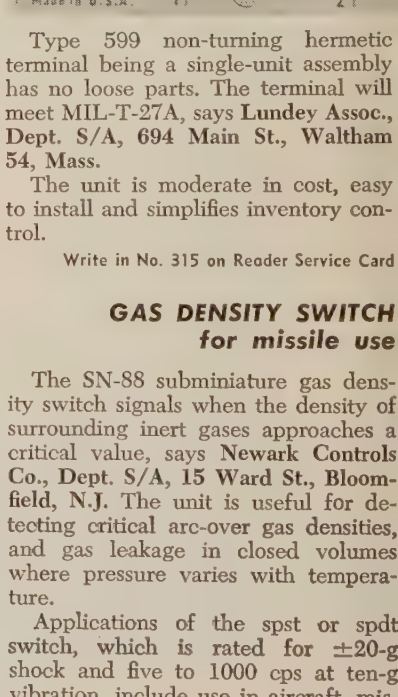

### POTENTIOMETERS simplify calibration

A new series of panel-mount trimmer potentiometers has simplified circuit calibration by making unnecessary the removal of covers or housings, says **Atohm Electronics, Dept. S/A, 7648 San Fernando Rd., Sun Valley, Calif.** Resulting advantages include a saving in time, and avoidance of accidental damage to precision components.

The panel-mount is fabricated of stainless steel. It is available as an integral part on all trimmer types, or as an accessory.

Write in No. 314 on Reader Service Card

### HERMETIC TERMINAL is single-unit assembly




Type 599 non-turning hermetic terminal being a single-unit assembly has no loose parts. The terminal will meet MIL-T-27A, says **Lundey Assoc., Dept. S/A, 694 Main St., Waltham 54, Mass.**

The unit is moderate in cost, easy to install and simplifies inventory control.

Write in No. 315 on Reader Service Card

### GAS DENSITY SWITCH for missile use

The SN-88 subminiature gas density switch signals when the density of surrounding inert gases approaches a critical value, says **Newark Controls Co., Dept. S/A, 15 Ward St., Bloomfield, N.J.** The unit is useful for detecting critical arc-over gas densities, and gas leakage in closed volumes where pressure varies with temperature.

Applications of the spst or spdt switch, which is rated for ±20-g shock and five to 1000 cps at ten-g vibration, include use in aircraft, missile, wave guide and electronic equipment. Accuracy of the actuation point is ±0.8 psi over a −85 to +200-deg F range, and the differential between the actuation and deactuation pressure is two psi. The device weighs two oz and is 2 1/32 in. long.

Write in No. 316 on Reader Service Card

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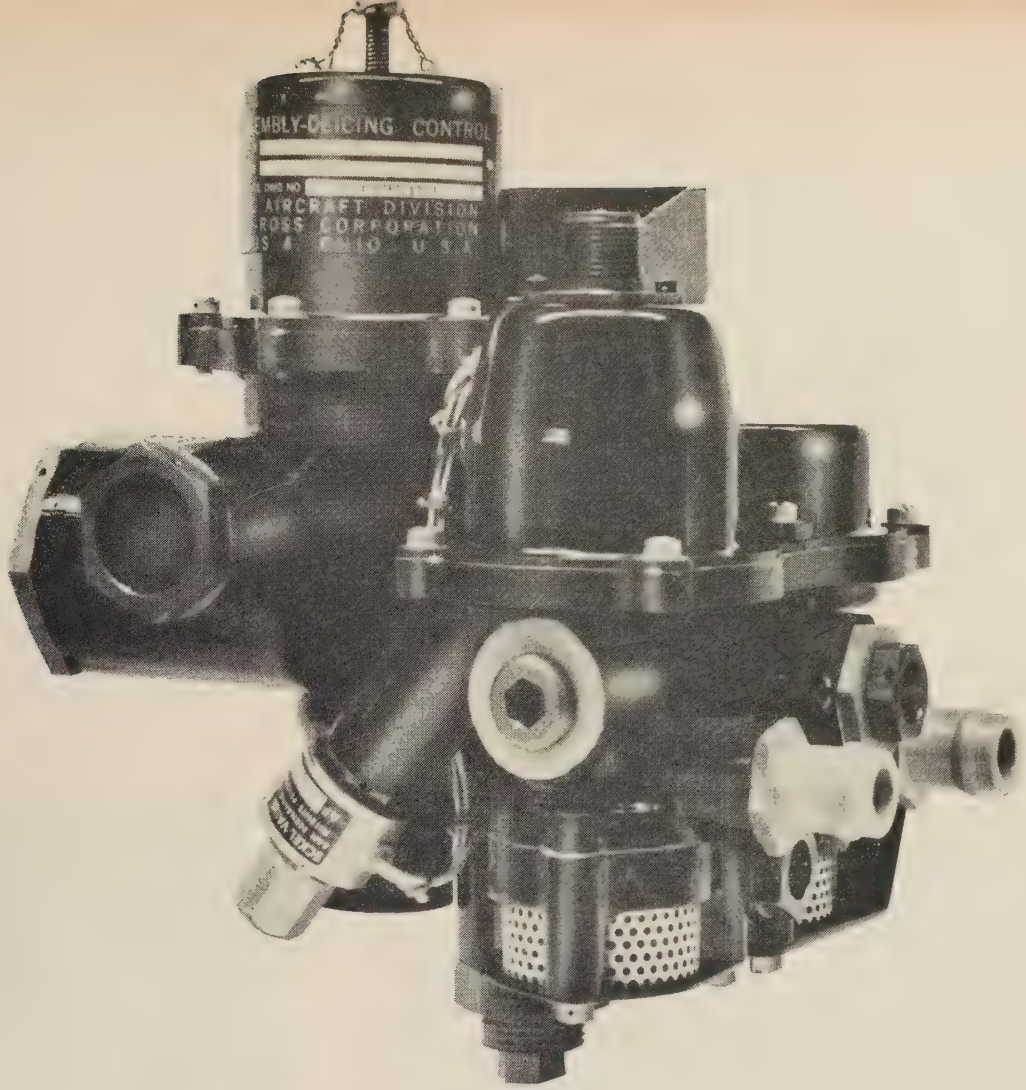


# JANITROL MAKES VALVES?

Next time you tackle an air regulating problem—actuation, tank pressurization, de-icing, air conditioning, or what have you—on aircraft, missiles, or ground support equipment, call Janitrol. We got a head start years ago in designing valves for combustion equipment, are now making valves in quantity with some of the most advanced production equipment in the business.

The valve illustrated is a good example of Janitrol's ability to combine several functions in a single unit (this one valve does the work that used to take seven) and thus bring about important weight savings.

We are currently working on hot valve problems as well as cryogenics. We also invite inquiries on high performance duct couplings, supports, and heat exchangers. Janitrol Aircraft, 4200 Surface Road, Columbus 4, Ohio.

**JANITROL AIRCRAFT**

*A division of Midland-Ross Corporation* MR

**pneumatic controls • duct couplings & supports • heat exchangers**
**combustion equipment for aircraft, missiles, ground support**

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ANOTHER ROSÁN
ENGINEERING ACHIEVEMENT

*SLIMSERT ... the insert designed to meet the requirements of the space age. A one piece stainless steel column embodying the ultimate in fastener design criteria.

HIGH STRENGTH • LIGHT WEIGHT • WIDE TEMPERATURE RANGE • NON CORROSIVE • POSITIVE EXTERNAL LOCK • EXTENDED LIFE INTERNAL LOCK • WASTE FREE INSTALLATION.

Can be installed in smallest boss diameter. Ideal for the replacement of wire type inserts.

*Send for 20 page Engineering Data Book, address Mr. E. G. Miller*



ROSÁN, INC.
2801 West Coast Highway • Newport Beach, California

**A trademark of Rosán Engineering Corp.*

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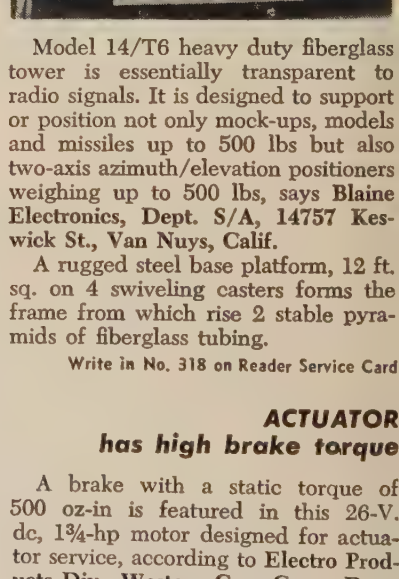
### HAND SPRAY GUN has broad uses

This hand held spray gun, weighing less than four pounds and 3½ inches long, is capable of operation on gases such as argon and nitrogen, at power levels to 40 kw. It is said to extend the range and capabilities of materials engineering into refractory metals, carbides, borides, silicides, and nitrides, according to **Giannini Plasmadyne Corp., Dept. S/A, 3839 So. Main St., Santa Ana, Calif.** It will spray steel, molybdenum, niobium, aluminum, magnesium, and many plastics.

Materials such as titanium carbide, tungsten, chromium or titanium can also be deposited on most ceramic base materials or metals without metallurgical, crystallographic, or chemical charges.

Write in No. 317 on Reader Service Card

### ANTENNA PATTERN TOWER made of fiberglass



Model 14/T6 heavy duty fiberglass tower is essentially transparent to radio signals. It is designed to support or position not only mock-ups, models and missiles up to 500 lbs but also two-axis azimuth/elevation positioners weighing up to 500 lbs, says **Blaine Electronics, Dept. S/A, 14757 Keswick St., Van Nuys, Calif.**

A rugged steel base platform, 12 ft. sq. on 4 swiveling casters forms the frame from which rise 2 stable pyramids of fiberglass tubing.

Write in No. 318 on Reader Service Card

### ACTUATOR has high brake torque

A brake with a static torque of 500 oz-in is featured in this 26-V. dc, 1¾-hp motor designed for actuator service, according to **Electro Products Div., Western Gear Corp., Dept. S/A, 132 W. Colorado Blvd., Pasadena, Calif.** The compound-wound reversible Model 49EC1 has a speed of 10,500 rpm and meets MIL-M-H609A requirements.

Length is seven in and diameter, four in.

Write in No. 319 on Reader Service Card

more on page 246

# THIS IS THE VOICE OF TIROS

## Radiation's Model 3115 Transmitter telemeters first weather pictures

The Tiros I weather satellite developed by RCA for NASA under technical direction of U. S. Army Signal Corps, embodies many innovations . . . but its telemetering transmitter is not one of them. Tiros' cloud-cover pictures are relayed to earth by Radiation's well-tried Model 3115 FM Transmitter. This "off-the-shelf" unit was chosen for its vital task because exhaustive tests and a fine performance record on other projects demonstrated its reliability.

Tiros carries two Model 3115 Transmitters. Each of these delivers 2 watts of linear FM output. Carrier frequency stability is within $\pm 0.01\%$.

For complete technical data on the Model 3115, write for a new bulletin, RAD B-102, to Radiation Incorporated, Dept. SA-6, Melbourne, Florida.

**THE ELECTRONICS FIELD ALSO RELIES ON RADIATION FOR...**

**RADIPLEX**—50-channel low-level multiplexer with broad data processing applications. Features rugged solid-state circuitry, almost unlimited programming flexibility, unique modular construction for compactness and exceptional ease of operation and maintenance.

**RADICORDER**—Multistylus recorder provides high-speed instantaneous readout for wide range of data acquisition or processing systems. Eliminates necessity of electronically translating complete data, thereby reduces computer work loads.

**TDMS** – Telegraph Distortion Monitoring System pinpoints type and source of trouble on teletype, data processing and similar communications links without interrupting traffic. Ultra-compact TDMS can replace most test equipment now required for teletype maintenance and monitoring.

RADIATION INCORPORATED

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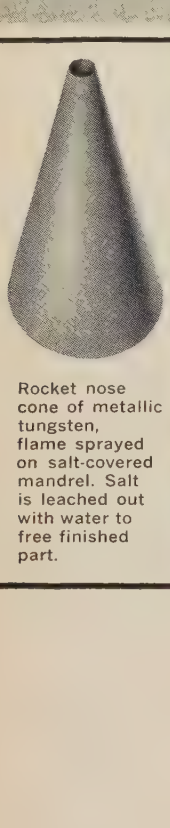
# Flame spray refractory coatings at high speed—low cost

**Alumina—zirconia—tungsten carbide—for protection against high temperatures—blast abrasion.**



Rocket nose cone of metallic tungsten, flame sprayed on salt-covered mandrel. Salt is leached out with water to free finished part.

METCO Type 2P ThermoSpray Gun flame sprays a wide range of material in powder form, including tungsten carbide. Plasma Flame spray equipment also available.

METCO Type KD Machine flame sprays alumina and zirconia in rod form; provides highest application speeds for guns of this type—over 90% deposit efficiency.

METCO offers a complete range of flame spraying equipment for applying coatings of refractories and other high melting-point materials. Automatic electronic controls provide push-button operation for high-speed production, maximum deposit efficiencies.

**METCO Bulletin 136B provides basic engineering and application data on flame sprayed coatings of metals, ceramics, carbides and other high melting-point materials. Send off the coupon or write.**

METCO®

## Metallizing Engineering Co., Inc.

Flame Spray Equipment and Supplies
1133 Prospect Avenue, Westbury, Long Island, N. Y.
In Great Britain: METALLIZING EQUIPMENT CO., Ltd., Chobham-near-Woking, England

Please send Engineering Data Bulletin on the METCO Flame Spray Processes.

name _____ title _____

company _____

address _____

city _____ zone _____ state _____

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### SHUT-OFF VALVE for gas generators

An hydraulically operated valve that terminates combustion in solid propellant gas generators by rapidly lowering pressure has been announced by **Aero Supply Mfg. Co., Inc., Dept. S/A, Corry. Pa.** Valve 33-2258-00 may be easily modified as to line sizes and configuration.

The hot-gas shut-off valve can also be adapted to actuate a piston-cylinder or to modulate flow.

Write in No. 320 on Reader Service Card

### MODULAR CONTROL SYSTEM is transistorized

This transistorized modular control system consists of a module case, preamplifier and power amplifier. Mounted in a compact chassis each of the amplifiers can be slid in or out of the case in seconds by means of a quick connect-disconnect plug, says **Airborne Accessories Corp., Dept. S/A, Hillside 5, N. J.**

The unit contains on moving contacts or relays and can drive motors up to 200 W. Use of three input channels enables the pre-amplifier to be utilized in systems having input command, rate and feedback loops.

Write in No. 321 on Reader Service Card

### MICROWAVE DIODE designed for L-Band

Type D-4097 point contact diode is designed for microwave mixer applications in the L-band frequency spectrum. The unit exhibits a maximum conversion loss of only 5.5 db with a maximum output noise ratio as low as 1.5 times, says **Sylvania Electric Products, Inc., Semiconductor Div., Dept. S/A, Woburn, Mass.** This loss is equivalent of a 2 db improvement in noise figure for a receiver whose IF amplifier noise figure would be 1.5 db on a 12 per cent increase in range.

Write in No. 322 on Reader Service Card

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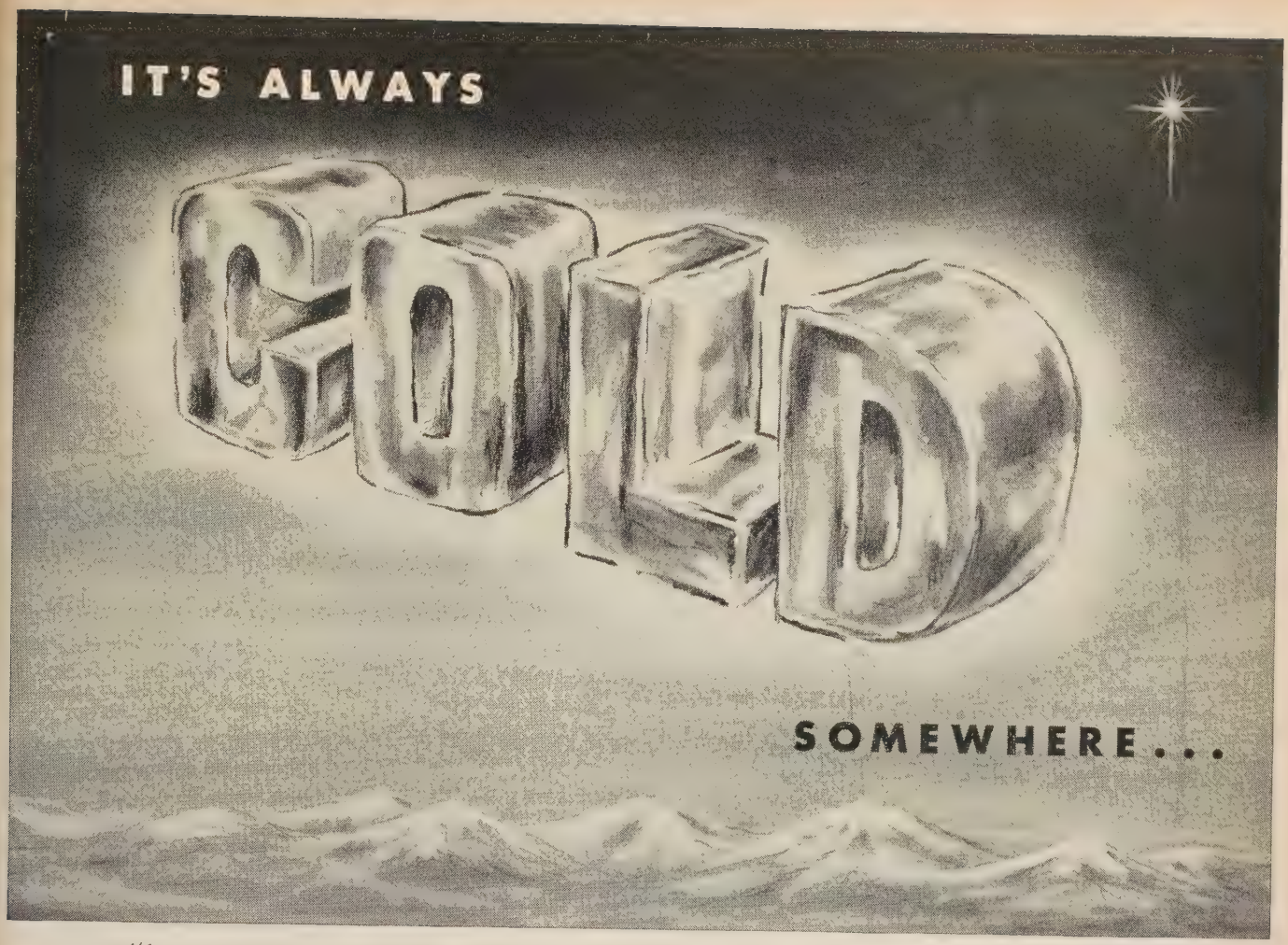

## And SAFEWAY Heating Blankets and Elements solve cold problems wherever they exist!

Maybe it's a basic defrosting problem in industrial refrigeration . . . or perhaps it involves the vital protection of aircraft from the icy upper atmospheres.

For these and scores of in-between applications, Safeway provides a *controlled heat* product, regardless of environmental temperatures. And people who know refrigeration depend on Safeway Heat Elements as a completely reliable and economical solution to defrosting problems in the commercial and industrial field.

Safeway's modern manufacturing facilities are devoted *exclusively* to the design, engineering and application of *controlled heat* for industry. Among the wide variety of Safeway heating blankets, woven and molded heating elements are:

- **heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft**
- **de-icing units for airfoil surfaces**
- **heating elements for all types of ground support equipment**
- **defrosting units for industrial and commercial refrigeration**
- **heating blankets for honeycomb and metal-to-metal bonding**

*For your copy of a fact-filled folder, please write:*

If it has to be heated (and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems carefully, and — without any obligation — submit an appropriate recommendation.

**Safeway HEAT ELEMENTS INC.**

**Middlefield Street • Middletown, Connecticut**

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REPUBLIC VALVES
FOR EVERY INDUSTRY

EXTRA HIGH PRESSURE FINE METERING

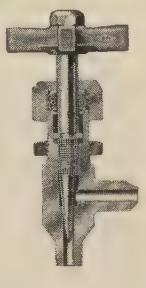


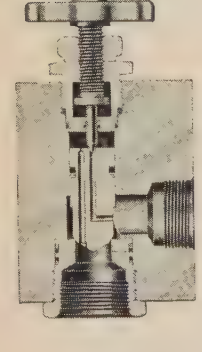
HIGH PRESSURE NEEDLE VALVE

10,000 psi hydraulic service. Forged stainless steel one-piece body. Panel mounting. Good flow characteristics, fine metering, easy to turn. Water, gas, oil and vacuum service, ⅛" to ½" pipe or straight thread tube connections.

MICROMETER ADJUSTMENT NEEDLE VALVE

Best for extra fine metering. Micrometer adjustment, precision taper stem. 5000 psi service −65° to 350°F., oil, water, etc. Brass, aluminum alloy, steel, or stainless steel body. ⅛" and ¼" sizes. Premolded or O-ring packing. Panel mounting.





5000 psi THROTTLE-FLO VALVE

Accurate throttling up to 5000 psi. Finger tip control. Pilot operation of large dynamically balanced piston. Full flow, yet accurate to 1/100 gpm through entire range. Positive seal. Low pressure drop. Aluminum alloy, ½", ¾", 1" internal straight thread connections. Hydraulic seals — others available.

HYDRAULIC BLEEDERS

Primarily used for bleeding air from hydraulic systems, for working pressures to 3000 psi at temperatures from −65° to 180°F.

Fluid control valves of many types have been developed and are manufactured by REPUBLIC. A wide line of quality standard valves includes needle, globe, check, plug, selector and relief valves, as well as other units for industrial, chemical, aircraft, missile and ground handling equipment.

Specialists in valving and manifold design to meet your specific application. Write for catalog.

*Distributors in principal cities coast to coast*

CHECK RELIEF SELECTOR GLOBE NEEDLE PLUG

251

RM REPUBLIC MANUFACTURING CO.

15655 BROOKPARK ROAD • CLEVELAND 35, OHIO

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## METAL TUBE SEALS take high pressures

A pressurized metal tube ring that withstands pressures up to 20,000 psi and temperatures above 1000 deg F has been added to the Gaseal line of **General Hermetic Sealing Corp., Dept. S/A, 99 E. Hawthorne Ave., Valley Stream, L.I., N.Y.** The seals, which are suggested for the aviation, missile and other industrial fields, contain an inert gas under pressure, normally about 600 psi for the average metal-to-metal joint.

The static hermetic seal formed by the rings will safely expand and contract with varying temperature. Gaseals are available to fit any joint and can be fabricated in any shape or size. Range for od is ½ to 96 in.

Write in No. 323 on Reader Service Card

## CIRCUIT EQUIVALENT has flip-flop characteristics

The first commercially available version of a "Circuit Equivalent" component with characteristics comparable to a flip-flop or bistable multivibrator is the Silicon Trigistor. The Trigistor is a silicon PNPN device with the unique property of triggered turn-off as well as triggered turn-on control at its base, says **Solid State Products, Inc., Dept. S/A, 1 Pingree St., Salem, Mass.**

The Trigistor is useful for memory counting, timing, gating, and logic functions while requiring fewer components to perform a given circuit function. Usually, a single Trigistor will perform the same function as two transistors plus several associated components.

Write in No. 324 on Reader Service Card

## TEST STAND checks transformers

Precise measurement of the response of linear variable differential transormers to linear core motion, independently of installation, is possible with the Model PMB-100-C test stand, says **Schaevitz Engineering, Dept. S/A, Pennsauken, N.J.** The transformer case is clamped in the mount, and a non-magentic, non-conductiive core rod positons and supports the core as the micrometer is adjusted.

The stand has five push-type binding posts for interconnecting the transformer and the test circuitry. Properly supported by test equipment such as a signal generator, voltmeter and oscilloscope, the stand can measure and test linearity, phase, input and output voltage, and operation at various frequencies.

Write in No. 325 on Reader Service Card

## SLIP RING ASSEMBLIES for radar applications

Slip ring assemblies, 38 in number, are components in radar rotating antenna circuits. Each unit includes two coaxial, seven shielded circuits, and 47 unshielded circuits, says **Superior Carbon Products, Inc., Dept. S/A, 9115 George Ave., Cleveland 5, Ohio.**

The 56 rings are of coin silver, two silver graphite brushes per ring. Speed is 15 rpm noise level below 0.002 V. Dimensions are 24 x 12 x 12 in.

Write in No. 326 on Reader Service Card

## TOGGLE SWITCH has new handle

The squared-off corners and flat sides of this new toggle switch handle not only improves panel appearance, but also permits 15-deg greater travel of the handle, says **Electrosnap Corp., Dept. S/A, 4218 W. Lake St., Chicago 24, Ill.** The unit is available in both dpdt and three-pole double-throw versions.

Each circuit is rated at five amps, 125 V ac; four amps, 30 V dc; and 2.5 amps, 30 V dc inductive.

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*more on page 250*



Write in No. 230 on Reader Service Card ➡

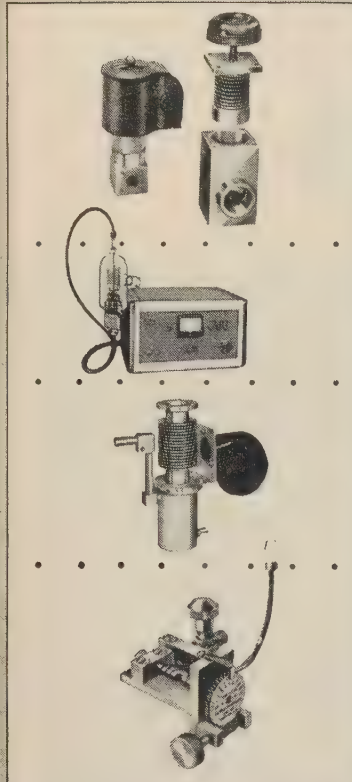
# BENDIX BRAKES—

## SURE GROUND CONTROL FOR 150-TON GIANTS

There's good reason why most of today's commercial and military jets rely on Bendix brakes. Products of the world's most experienced brake manufacturer, they are specially designed and built to meet the extra-heavy ground control demands of these high-performance aircraft. In fact, "Brakes by Bendix" signifies safe, sure ground control—*whatever* the aircraft.

Bendix PRODUCTS DIVISION South Bend, IND.

trouble-free
HIGH VACUUM COMPONENTS



VALVES...GAUGES...CONTROLS
PUMPS...ACCESSORIES

**VALVES:** Bellow sealed, brass & stainless steel • Manual • Solenoid • Pneumatic

**GAUGES & CONTROLS:** Non-burnout Ionization gauges, Bayard-Alpert type • Ultra-stable ionization gauge controls • Cold cathode discharge gauges and controls • Thermocouple gauges and controls

**PUMPS:** Diffusion pumps, air-cooled & water-cooled • Mechanical pumps, complete stock

**ACCESSORIES:** Standard and variable leaks • Quick couplings • Cold traps, Baffles • Electric degassing gun • "O"-ring sealed flanges • *Many others.*

FREE TECHNICAL BULLETINS or complete CATALOG. Write Department A-1437.

Veeco VEECO VACUUM CORP.
86-M Denton Avenue, New Hyde Park
Long Island, New York
HIGH VACUUM & LEAK DETECTION EQUIPMENT

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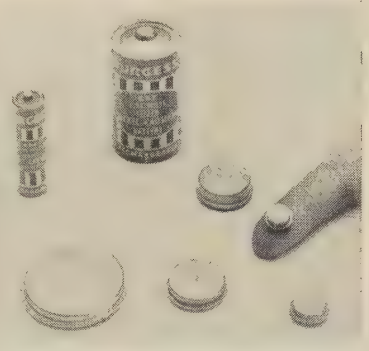
## *BATTERIES are nickel-cadmium types*

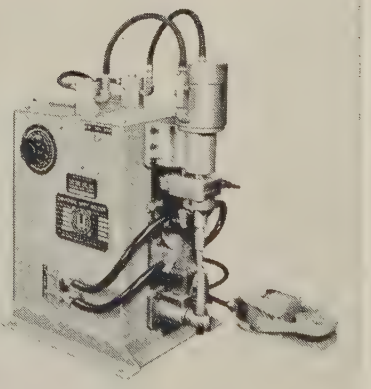


A line of rechargeable nickel-cadmium cells and batteries featuring hermetically-sealed construction that eliminates routine maintenance and the addition of liquids has been introduced by **Burgess Battery Co., Dept. S/A, Freeport, Ill.** The batteries may be recharged hundreds of times, respond to either a slow or fast charge, and are not affected adversely by long storage periods, either in a charged or discharged state.

Individual cells rated at 1.25 V are available in eight sizes. They include six very small button-type units, and penlight and standard flashlight sizes. Multiple cell types in numerous voltages are also available.

Write in No. 328 on Reader Service Card

## *BENCH WELDER for critical jobs*



This press type bench welder is for extra fine and critical welding. Capacities range from 5 to 50 KVA. It is air actuated, has adjustable upper and lower arms and holders, says **Universal Electric Arc, Inc., Dept. S/A, 152-1 Jelliff Ave., Newark 8, N. J.** It is equipped with a foot switch.

A light metal ram operating in a lineal ball bearing sleeve and a precision diaphragm cylinder help its special adaptability for critical work.

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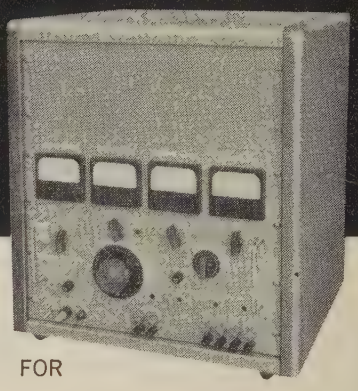
*more on page 252*

WALLSON
0 To 20 AMPERES
DYNAMIC RECTIFIER ANALYZER
Model 141A



FOR

- INCOMING INSPECTION
- ON-LINE INSPECTION
- LABORATORY USE

This dynamic rectifier test set, with independent forward current and reverse voltage controls, is completely self-contained and measures average forward voltage drop and reverse current of any type of semi-conductor rectifier rated to 20 amperes forward current and 1000 volts PIV., in accordance with proposed JEDEC specifications.

- **75 ampere Surge Test unit available for military testing.**

OTHER WALLSON PRODUCTS

- Automatic High Vacuum Exhaust Equipment
- TWT Power Supplies
- Dynamic & Life Test Equipment for Semi-conductor Rectifiers with Ratings up to 500 Amperes and 2500 Volts

WRITE TODAY
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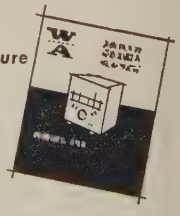
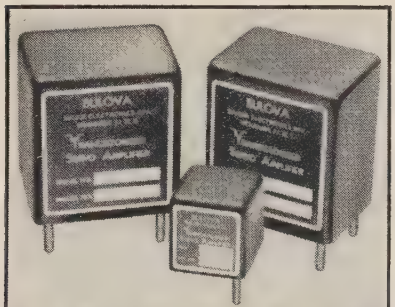


WALLSON ASSOCIATES, INC.
912-914 WESTFIELD AVE.
ELIZABETH, NEW JERSEY
FLanders 1-0700

Write in No. 233 on Reader Service Card

# BULOVA
# 3.5, 6, 12W
# SERVO AMPLIFIERS



**BULOVA**
ELECTRONICS
DIVISION

In addition to their "greater-than" conversions at high temperatures, the new Bulova Servo Amplifiers promise maximum flexibility in systems design with a minimum of ounces and inches.

The all-silicon transistors potted in these amplifiers assure continuous operation from −50°C. to +125°C. and provide maximum wattage output per unit volume and weight. Under varied and severe environmental and operating conditions, Bulova Servo Amplifiers exhibit outstanding performance, portray the following characteristics: shock and vibration resistance, thermal and electrical stability.

If your requirement for a 3.5, 6 or 12w servo amplifier is a little more sophisticated, a bit more demanding than the average, take it to Bulova. There's a stock unit suited to your needs and budget. For additional data write Department 1671, Bulova Electronics, Woodside 77, New York.

**Write in No. 234 on Reader Service Card at start of Product Preview Section**

New DuPont sheet explosive gives high destructive force, yet trims weight and space requirements.

# WRAP-AROUND EXPLOSIVE

## trims ounces and inches from rocket and missile destructor designs

You conserve valuable space when you put this wrap-around destructor to work.

You bend and cut it like plastic sheeting, snug it right up against the surfaces to be destroyed, almost like a second skin.

You can use it in full sheets, patches, circles, stars, crosses, etc.—whatever shape is most effective for your purposes.

DuPont EL-506A Flexible Sheet Explosive comes in 10″ x 20″ sheets and in thicknesses from 0.084″ to 0.328″, depending on the explosive force you need.

You save weight because EL-506A gives maximum cutting action through intimate contact between explosive and surface, plus directional application of the explosive force. The sheet explosive itself weighs only 2 to 8 grams/sq. in.

You can design freely with this new DuPont explosive for such functions as: destruction of secret components on completion of a flight or in a misfire, separations, diaphragm opening, destroying spent propellant cases, etc.

### Easy to use

El-506A cuts easily with a linoleum knife, can be molded to fit any contour and easily cemented into place. It is relatively insensitive to shock and requires a special initiator.

Our technical bulletin A-8525 can tell you more about EL-506A. Write to Du Pont, Explosives Department, 6539 Nemours Building, Wilmington 98, Delaware.

# DU PONT EL-506A

DU PONT Flexible Sheet Explosive

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Write in No. 235 on Reader Service Card at start of Product Preview Section

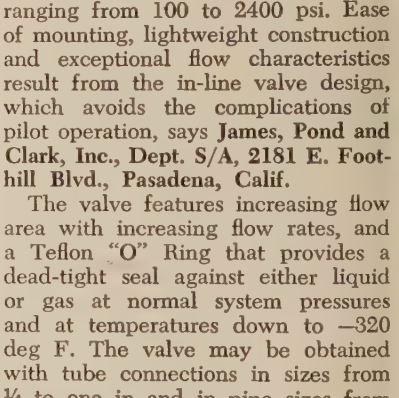

### *SUPER-ALLOY for high temperatures*

A high temperature super-alloy developed for Jet engine production is said to have improved corrosion resistance and high temperature strength. Detailed performance characteristics are still classified and have not been released, according to **American-Marietta Co., Dept. S/A, 101 E. Ontario St., Chicago 11, Ill.** It is covered by patent applications in the United states and foreign countries.

The alloy is said to have been approved for production of gas turbine aircraft engines.

Write in No. 330 on Reader Service Card

### *LOX VALVE has wide pressure range*



The Model K5120T relief valve for liquid oxygen or nitrogen systems is available with cracking pressures ranging from 100 to 2400 psi. Ease of mounting, lightweight construction and exceptional flow characteristics result from the in-line valve design, which avoids the complications of pilot operation, says **James, Pond and Clark, Inc., Dept. S/A, 2181 E. Foothill Blvd., Pasadena, Calif.**

The valve features increasing flow area with increasing flow rates, and a Teflon "O" Ring that provides a dead-tight seal against either liquid or gas at normal system pressures and at temperatures down to —320 deg F. The valve may be obtained with tube connections in sizes from ¼ to one in and in pipe sizes from ⅛ to one in.

Write in No. 331 on Reader Service Card

### *LEAK STANDARD halogen detectors*

This leak standard for calibrating and checking operation of halogen-sensitive leak detectors is said to make calibration practical for all users of halogen leak detection equipment. It is portable, weighs about 3 lbs and provides an adjustable reference leak of known rate, according to **General Electric Co., Instrument Dept., Dept. S/A, West Lynn, Mass.**

It releases refrigerant gas through a tiny capillary tube at manually controlled rates, indicated on a circular dial, ranging up to about 3 ozs a year.

Write in No. 332 on Reader Service Card

*more on page 254*

# COMPLETE SERVO ASSEMBLIES

**We are not an assembly station. We are a manufacturer!**

Steel and copper come into our factory. Housings are turned and gears are hobbed from the solid stock. Laminations are stamped from strip steel. Copper is wound right off the reel.

Every operation between raw stock and servo assembly is performed in our own plant, under our own supervision. And because we exercise this complete control over manufacture, we can honestly vouch for the quality and reliability of every motor, generator, synchro, and gear train carrying our name.

Undivided responsibility isn't a new idea by any means, but it is increasingly difficult to find in this age of overspecialization. If you'd care to sample the benefits of this integrated approach, why not call on us now?

**SERVO ASSEMBLY** – Type 9 motor generator driving two Type 11 CT synchros through a slip clutch and a gear train having ratio of 1500 to 1.

**DAYSTROM, INCORPORATED**

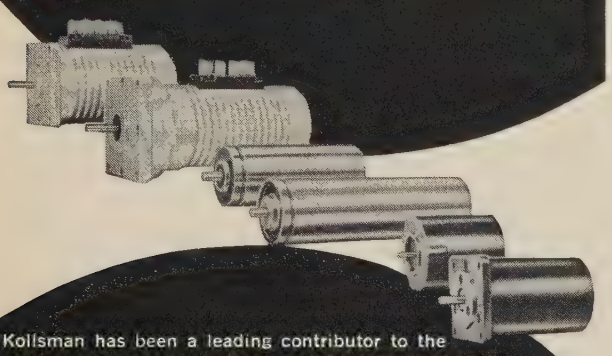
TRANSICOIL DIVISION **WORCESTER • MONTGOMERY COUNTY • PENNSYLVANIA**

Write in No. 236 on Reader Service Card at start of Product Preview Section

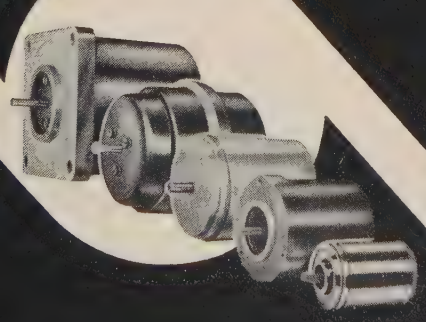
special purpose motors

. . . for exacting requirements

SYNCHROS · RESOLVERS · INDUCTION GENERATORS
MOTOR GENERATORS · HYSTERESIS SYNCHRONOUS MOTORS
DRAG CUP MOTORS · GEARED UNITS · P.M. GENERATORS



Kollsman has been a leading contributor to the state of art in special-purpose motor design since 1942. Today its total cumulative experience represents one of the greatest productive sources for special motors that must meet unusually high reliability/performance needs . . . under extremes of temperature, shock, vibration, humidity and other environmental conditions. Either 60 or 400 cycles; complete line of servos. Kollsman Motor designs will enhance your system design.



kollsman motor corporation
MILL STREET, DUBLIN, PENNSYLVANIA
Subsidiary of Standard Coil Products Co., Inc.

Write in No. 237 on Reader Service Card



### TESTER
### cycles relays

This unit will cycle relays for testing under "dry-circuit" circuit conditions. The relay contacts are tested dynamically at open circuit voltages as low as 1 mv with closed circuit currents as low as 1 microamp says **Shasta Electronic Co., P.O. Box 316, Dept. S/A, Palo Alto, Calif.**

An electronic gate is provided to eliminate erroneous miss indications.

Write in No. 333 on Reader Service Card

### INDICATOR FILTERS
### give pressure signals

This high or low flow filter has a mechanical indicator to provide a differential pressure signal when cleaning is required. It is capable of withstanding full-line pressure, 4500 psi, and is operable under extreme temperature conditions. It can be used for any fluid system in which differential pressure can be used for measurement, says **Purolator Products, Inc., Dept. S/A, Rahway, N. J.** It uses a nonmagnetic, pressure sensitive piston which, when actuated by changes in differential pressure across the filtering element, transmits linear motion to an indicating mechanism which releases a visual button.

Manual reset is accomplished by depressing the indicator button until it automatically engages a detent, and remains in a hidden position.

Write in No. 334 on Reader Service Card

### THERMOMETER
### can be reset

The Model 142 thermometer, made with stainless steel stem, tip and mounting, will stand up under hard laboratory and production use, according to **Pacific Transducer Corp., Dept. S/A, 11836 W. Pico Blvd., Los Angeles 64, Calif.** Design of the device permits resetting and recalibration by means of a simple procedure.

The waterproof unit has a range of zero to 220 deg F. Overall diameter of the dial is 2⅛ in, stem length is six in, stem diameter is ¼ in, and mounting diameter s .400 in.

Write in No. 335 on Reader Service Card

### ACTUATORS
### are reliable

The miniature electromechanical actuators in this line derive their superior reliability from design simplicity and environment-proof construction, says **Nash Controls, Inc., Dept S/A, 69-73 Summit St., Newark 3, N.J.** They are useful in applications requiring rotary and linear motion.

Very low backlash, accurate positioning, adjustable limit switches, and non-reversible gear train are among the features of the unit, which complies with MIL-A-8064A and MIL-E-5272A for aircraft, missile and electronic applications. Either ac or dc motors are available.

Write in No. 336 on Reader Service Card

### DC AMPLIFIER
### is transistorized

Model DA-12 dc amplifier is completely transistorized and is supplied with both differential input and differential output circuits which also function with either or both input and output single-ended; says **United Electro Dynamics, Dept. S/A, 200 Allendale Road, Pasadena, Calif.**

The unit features only 5.0 microvolt peak-to-peak noise, a response time to a step function input of only 7 Microsec and an overload recovery time of 50 microsec and a special heat control system which insures low drift.

Write in No. 337 on Reader Service Card

more on page 256

# VĀP-AIR

## PROPORTIONAL POWER WINDSHIELD CONTROL

- applies power proportional to heat load requirement for windshield anti-icing
- simplest, lightest in weight
- immediate response to changes in ambient temperature
- proven solid-state components
- proportional temperature controlled warm-up feature available to eliminate initial thermal and electrical shock

Complete system in one small package—no external transformers, contactors or radio noise suppression needed. Eliminates adjustment of power taps and periodic windshield matching. Drastically reduces windshield thermal and electrical shock.

**TYPICAL SPECIFICATIONS:**

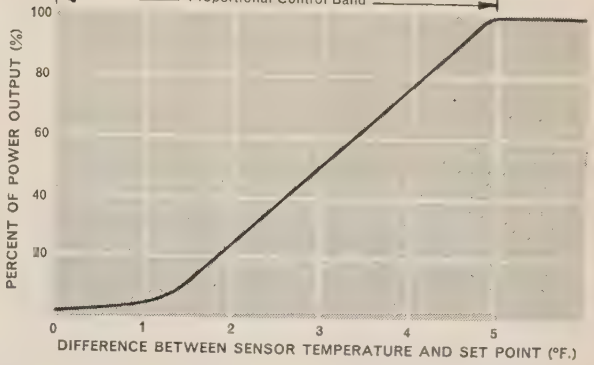
| | |
|---|---|
| Normal operating voltage | 115v. or 200v. single phase, 400 cycles |
| Control tolerance | ±2½°F of set point |
| Ambient operating temperature | —65° to 160°F. |
| Output power (with 2 channels) | 1.6 KW and 1.6 KW |
| Output efficiency | 85 to 90% |
| Dimensions | 7" x 5½" x 5" |

**VĀP-AIR . . . SPECIALISTS IN AIRCRAFT THERMAL CONTROLS FOR NEARLY 20 YEARS**

*Entire systems and a complete line of sensors, electronic controls and precise voltage regulation, electro-pneumatic and electro-mechanical valves, advanced hot-air in-line valves and pressure regulators, electric power controllers and heat exchange equipment—for aircraft, missiles and ground support.*

for complete technical information and applications write:

TYPICAL RESPONSE CURVE SHOWING CONTROL PROPORTIONAL BAND VERSUS POWER APPLIED TO WINDSHIELD HEATER




New York • St. Paul • Denver • Washington
Philadelphia • Seattle • San Francisco • Houston
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VĀP-AIR THE AERONAUTICAL DIVISION OF
VAPOR HEATING CORPORATION, DEPT. 34-F
80 East Jackson Blvd., Chicago 4, Illinois

Please send information on the Vāp-Air Proportional Power Windshield Control.

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FIRM_____

ADDRESS_____

CITY, ZONE, STATE_____

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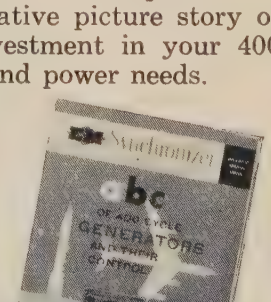
# Ground Power Problems? ...Here is the Answer!

Whatever your requirements in 400 cycle ground power equipment, E-M's large staff of specialists, with unmatched 400 cycle generator experience, can help. Missiles and jet aircraft that now have the advantages of E-M's imaginative engineering of 400 cycle ground power generators include Titan, Nike-Hercules, Snark, Matador, Hound Dog, B-47, B-58, and B-52.

Designing and building 400 cycle generators to meet the exacting requirements of missile and jet applications requires a big investment in experienced, technical manpower and plant facilities. Ask your nearby E-M Field Engineer to show you his copy of "Ground Power for Space". It's an informative picture story of E-M's investment in your 400 cycle ground power needs.

**FREE 28-PAGE ILLUSTRATED BOOKLET** offers many answers to your 400 cycle ground power questions. Write the factory for a free copy of "ABC of 400 Cycle Generators and Their Control". It's packed with useful information about performance characteristics and mechanical construction of 400 cycle ground power generators.




E-M ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

2600-TPA2220A

Write in No. 240 on Reader Service Card at start of Product Preview Section




## *ELECTROFORMING for aircraft unit*

This example of electroforming, a process of the electro-chemical deposition of metal, provides a simple means for the manufacture of complex metal shapes, says **Electroform Corp., Dept. S/A, U. S. Route #1, So. Norwalk, Conn.**

The process provides the advantages of close dimensional control, production of complex shapes in stress-free nickel, metal formed on mandrels or in molds, and high degree of finish without further machining.

Write in No. 338 on Reader Service Card

## *SOLAR CELLS feature high efficiency*

The TI N2000 series diffused-junction silicon solar cells feature efficiencies as high as 9 per cent. The solar cells are available in a rectangular configuration, measuring 1 by 2 by 0.05 cm. both in single units and single arrays, says **Texas Instruments Inc., Semiconductor-Components Div., Dept. S/A, P.O. Box 312, Dallas, Texas.**

The TI N2009, one of the series provides a typical efficiency of 9 per cent and a spectral emissivity of 0.7 at 4 microns wavelength illumination.

Write in No. 339 on Reader Service Card

## *CAMERA for circuit research*

Called the Micro Module Camera, this unit features a specially developed lens capable of resolving micro-inch circuitry. Materials, such as conductors, insulators or resistors are then printed with a photographic negative into a geometric pattern, says **Burke & James, Inc., Dept. S/A, 321 S. Wabash Ave., Chicago 4, Ill.**

Although previously classified secret, production schedules for general use of the photographic system are currently being prepared.

Write in No. 340 on Reader Service Card

### PRESSURE SWITCH for continuous use

This in-line pressure switch is for hydraulic, fuel and pneumatic systems. A piston-type pressure sensing unit performs accurately under fast continuous operation. It is unaffected by jarring or vibration. A compression point controls the point of actuation and may be adjusted externally to accommodate minor changes, says **Fisher Controls, Inc., Dept. S/A, 1928 Lincoln Blvd., Santa Monica, Calif.** Standard units with ¼ inch male pipe pressure connection and ½ inch male pipe electrical conduit connection are available from 50 to 3500 psi.

The valves weighs two ozs, are 3 inches long and will operate from —65 deg F to 165 deg F with an electrical rating of 15 amps at 120 V ac.

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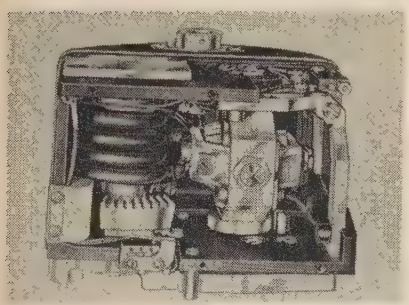
### MISSILE GYRO is low in cost

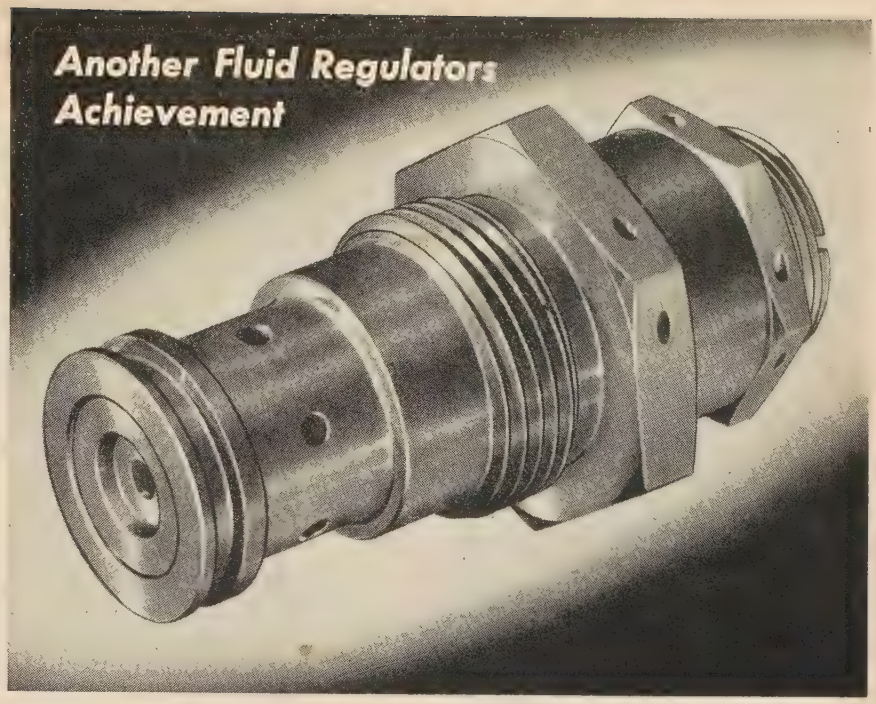


The WG-14 gyroscope, designed to guide short range missiles and target drones for a period of several minutes, can be produced for under $200, says **Precision Instrument Co., Dept. S/A, 221 Crescent St., Waltham 54, Mass.** At the launching signal, the rotor of the two-deg-of-freedom gyro is instantly energized by a wound helical spring, and with the rotor up to speed, the gyro uncages and acts as a free gyro during flight.

The spin axis is along the pitch axis of the missile, the outer gimbal is along the roll axis, and the inner gimbal is along the yaw axis. The angle of roll is indicated by a potentiometer pick-off.

Write in No. 342 on Reader Service Card

*more on next page*


# NEW Cartridge Flow Regulator

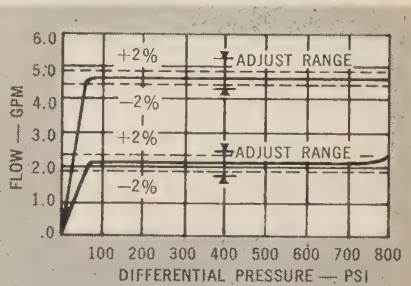
- **Maintains constant flow to the system when pump output varies**
- **Assures constant flow under varying upstream and downstream pressures**

Developed and produced for use in a multi-valve manifold, this small, lightweight valve eliminated connectors, fittings and lines. It reduced leakage points and weight, and permitted system design engineers greater design freedom.

Designed in close cooperation with the customer's engineering department, this valve illustrates the capabilities of Fluid Regulators to meet critical flow, size and weight requirements. Contact us today, for prompt action on your specific problems.

SPECIFICATIONS

- Regulated Flow: 0.1 gpm to 6.5 gpm with various combinations of springs and orifices. Factory Set—with limited field adjustment available.
- Regulation:
  ± 10% for flows 0.1 to 1.5 gpm
  ± 5% for flows 1.5 to 6.5 gpm
- Pressure Drop: 25 psi at high flows —50 psi at low flows
- System Pressure: to 2,000 psi
- Proof Pressure: 3,000 psi
- Burst Pressure: 5,000 psi
- Weight: 4 oz.
- Temperature: —65° F to + 275° F
- Fluids: any fluid compatible with materials
- Materials: aluminum alloy and stainless steel
- Finishes: aluminum alloy parts hardcoated — stainless steel passivated
- Designed to meet MIL-V-8566




These specifications may be changed to meet your specific requirements.

**Fluid Regulators CORPORATION**

313 GILLETTE STREET • PAINESVILLE, OHIO • ELmwood 2-3319

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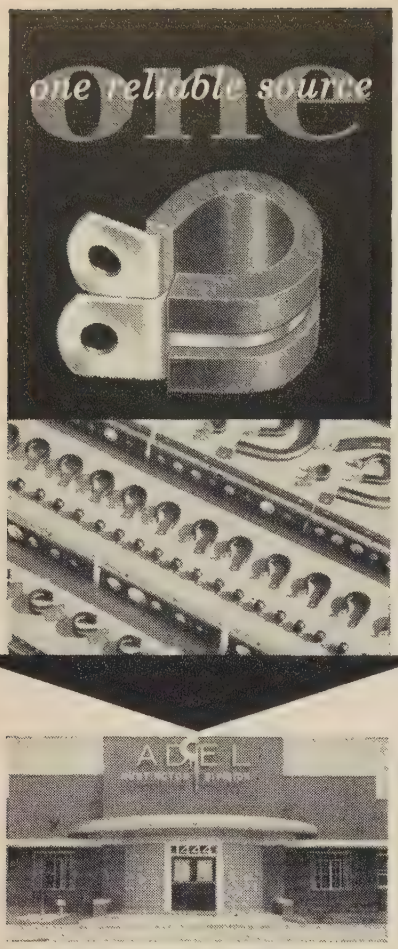


*for all your*

**CLIP, BLOCK** *and*

**HARNESS STRAP**

*needs!*

ADEL offers the widest variety of LINE SUPPORTS in the World . . . 19,000 different types and sizes for safe, vibration-free, positive support in all types of aircraft, missiles, rockets, ordnance, automotive and original equipment of all kinds.

SAFETY . . . FLEXIBILITY . . . DURABILITY . . . ECONOMY . . . SERVICE FITTED . . . SERVICE TESTED . . . SERVICE APPROVED

Illustrated are but a few of the World's most complete line of Line Supports that meet or exceed all applicable specifications and/or requirements. Whatever the application—STANDARDIZE ON ADEL—the leader in completeness of line, service and reliability.

Reliability

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SPECIFICATIONS ARE AVAILABLE TO AIRCRAFT, MISSILE AND ORIGINAL EQUIPMENT MANUFACTURERS . . . WHAT ARE YOUR REQUIREMENTS?

Direct inquiries to Huntington Division
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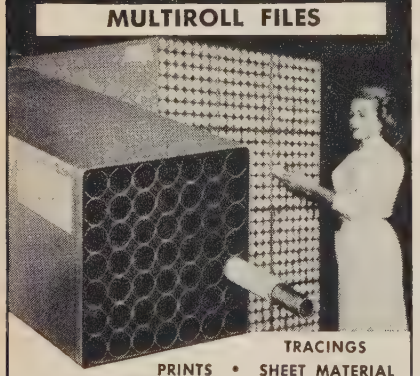
**MULTIROLL FILES**



TRACINGS
PRINTS • SHEET MATERIAL

QUICK, FILING AND WITHDRAWAL

| Depth | 11¼" | 22¼" | 30½" | 36½" | 42¼" |
|---|---|---|---|---|---|
| 49 Tube 1¾" I.D. MODEL | 49AB $7.50 | 49CD $9.50 | 4930 $12.80 | 4936 $13.80 | 4942 $14.80 |
| 25 Tube 2¼" I.D. | 25AB $7.00 | 25CD $9.00 | 2530 $11.80 | 2536 $12.80 | 2542 $13.80 |

Shipping Weight

| | | | | | |
|---|---|---|---|---|---|
| Model 49 | 8 lbs. | 12 lbs. | 15 lbs. | 18 lbs. | 20 lbs. |
| Model 25 | 6 lbs. | 10 lbs. | 13 lbs. | 15 lbs. | 17 lbs. |

ENAMELED DARK GREEN OR MED. GRAY - State Color

JR 36 — 9.50 SET of TWO

Designed to Mount Under Board—Mounting Brackets Furnished. Gray Only.

Sold in Sets Only—2 JR36 Per Set

8 lbs. Ship. Wt.

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ROLL & FILE SYSTEMS, INC. P. O. BOX 3863 B DETROIT 5, MICH

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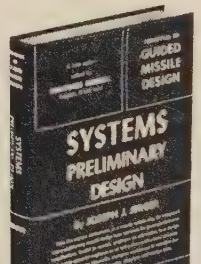


**SYSTEMS PRELIMINARY DESIGN**

By Joseph Jerger
*Consulting Engineer*

This important unifying volume to the series "Principles of Guided Missile Design" covers at length the various interrelationships that exist in the preliminary systems design of a guided missile. Useful data from important branches of engineering and science involved in missile design are presented in convenient form, and illustrative problems are carried out in complete numerical detail. *640 pages, $14.75*

D. VAN NOSTRAND COMPANY, INC.
Princeton, New Jersey

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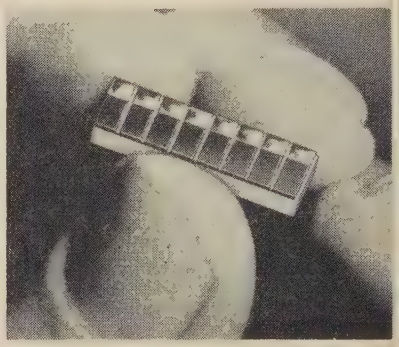
### *PNEUMATIC VALVE is highly sensitive*

This pneumatically operated air valve is extremely sensitive and will operate from the full open to the full closed position with a change in signal pressure of 1 psi or less depending on the valve size required. The signal pressure and the controlled pressure are isolated from each other, says **Dynamic Controls Corp., Dept. S/A, 30 Thomas St., E. Hartford, Conn.**

The unit, designed for aircraft and missile applications, weighs only 0.3 lbs, but can be subjected to temperatures of 360 deg F.

Write in No. 343 on Reader Service Card

### *PHOTOCELLS for data processing*



These silicon readout photocells are designed for computer and data processing where rapid detection of light passing through punched cards or tape is required. The units feature extremely fast response time in the order of 10 microsec, says **International Rectifier Corp., Dept. S/A, 1521 E. Grand Ave., El Segundo, Calif.**

Each matrix is made up of a multiple array of individually-segmented silicon cells. Light energy striking a particular segment will cause power to flow from that segment only. The units exhibit negligible temperature dependence, long life, uniform response from cell to cell and rugged construction.

Write in No. 344 on Reader Service Card

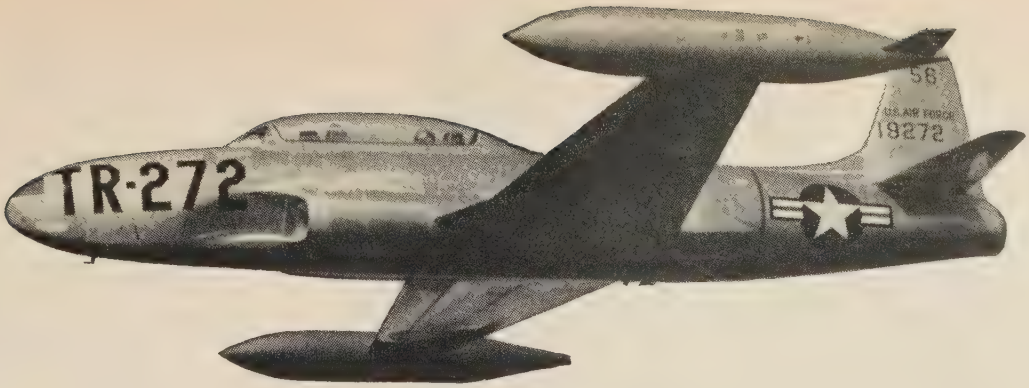
### *PUSHBUTTON SWITCH is single-throw*

This push-on, push-off, single pole, single throw push button switch is rated at 6 amps, 125 volts and 3 amps, 250 volts. A high cycle life switch with a positive switching action result from the internal armature design and heavy silver contact, says **Sargent Electric Corp., Dept. S/A, R-1, 630 Merrick Road, Lynbrook, N.Y.**

The quick make, quick break switch is specifically for appliances and electronic apparatus.

Write in No. 345 on Reader Service Card

*more on page 260*



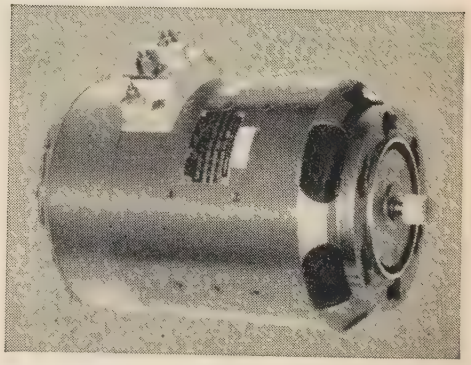

# Why jet trainers depend on Bendix Generators

Nothing is more important to the successful training of fledgling airmen than proper equipment . . . equipment that delivers dependable, topnotch performance. That's one of the reasons Bendix Red Bank Generators are so widely used on training aircraft of all types.

Training aircraft rely on Bendix Red Bank Generators to provide the vital electric power for radio, radar, navigation aids, instruments and other equipment.

The 30B43 generator shown is a 400 ampere DC machine. It will produce 300 amperes with 120° C. cooling air. It has a wide speed range (3,000-8,000 RPM), and weighs only 65 lbs. It is ideally suited for use on all types of trainers.

For more information about



Bendix Generators and their long record of successful service in all types of aircraft, write to BENDIX RED BANK DIVISION, EATONTOWN, NEW JERSEY.

West Coast Office: 117 E. Providencia, Burbank, Calif. Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y. Canadian Affiliate: Aviation Electric, Ltd., P.O. Box 6102, Montreal, Quebec.

*Lockheed's T-33 and North American's new T2J are equipped with Bendix Red Bank Type 30B43 DC Generator. Makes good sense to train air cadets in the finest trainers equipped with the finest accessories!*

Red Bank Division
EATONTOWN, N. J.

The Bendix Corporation

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Whether your servo application is in the challenging under-water environments of the history-making Skate or in the severe blast-off environment of the Polaris, you now can design your equipment or system smaller and better with an IMC servo ■ New advances in sub-miniaturization and motor performance ensure top operating characteristics for your systems applications. Size 5 through 18, high torque-to-inertia ratio, encapsulated for extra ruggedness, broad range of gear ratios, meet latest MIL environmental specifications ■ IMC engineers are ready to assist you in your servo design needs. Take advantage of their special servo know-how. Chances are they will save you time and money . . . plus provide you with a motor that completely fulfills your particular requirements ■ Write for additional technical information to:




**imc Magnetics Corp.**
570 MAIN STREET/WESTBURY, LONG ISLAND/NEW YORK/EDGEWOOD 4-7070

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### ANCHOR NUT *for high temperatures*

The Kaylock F19270 and F19271 anchor nuts are high-tensile, self-locking, all-metal units designed for high temperature applications requiring high torque-out and push-out characteristics, says **Kayner Mfg. Co., Inc., Dept. S/A, Box 2001 Terminal Annex, Los Angeles 54, Calif.** The F19270 is made of A286 stainless for 1200-deg F service, and the other, of M252 for 1400-deg F. service.

Retainers may be of any material compatible with the structure to which they are fastened.

**Write in No. 346 on Reader Service Card**

### CENTRIFUGES *for missile testing*

Large centrifuge acceleration test machines for use in the aircraft and missile fields are being produced by **The Rucker Co., Dept. S/A, 4709-H San Pablo Ave., Oakland 8, Calif.** Such test machines have been added to the facilities of a number of aircraft and missile companies and manufacturers in allied fields.

The Rucker line includes equipment with acceleration ratings to 150 g and test radii from 18 in to 35 ft.

**Write in No. 347 on Reader Service Card**

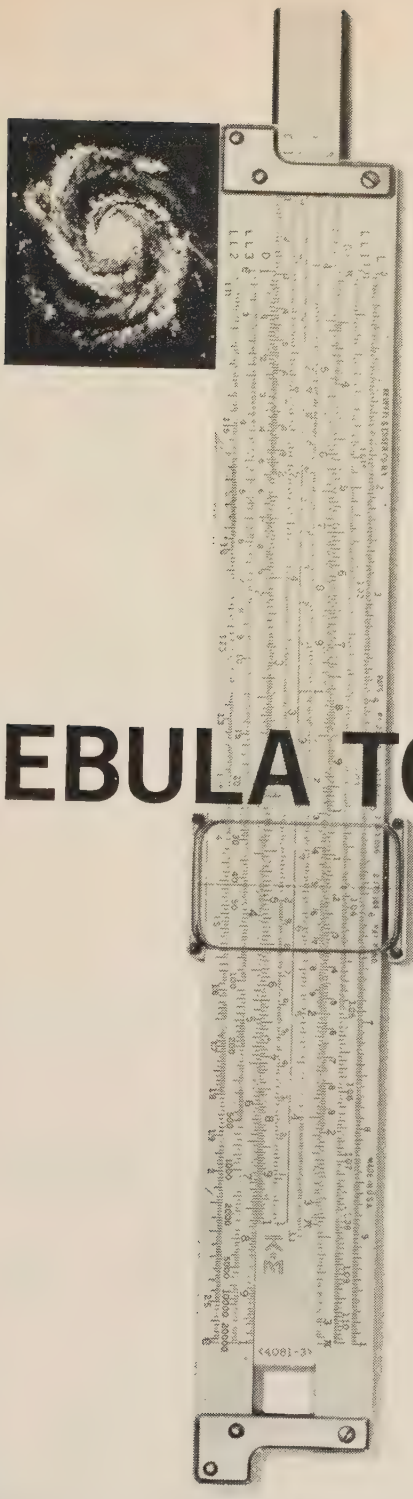
### SYNCHRO POSITIONER *meets military specs*

This dividing head is intended for the electrical error tests of synchros in accordance with BuOrd specification MIL-S-20708A. It is easily adaptable to all shaft and housing configurations from size 8 to size 37, says **Theta Instrument Corp., Dept. S/A, 48 Pine St., E. Paterson, N.J.**

The unit has an angular accuracy of 20 sec-of-arc at the coupling output with a range of 360 deg. A detent mechanism insures positioning at 5 deg intervals. Positioning at all other angles is done by a continuous, fine-angle device.

**Write in No. 348 on Reader Service Card**

*more on page 262*



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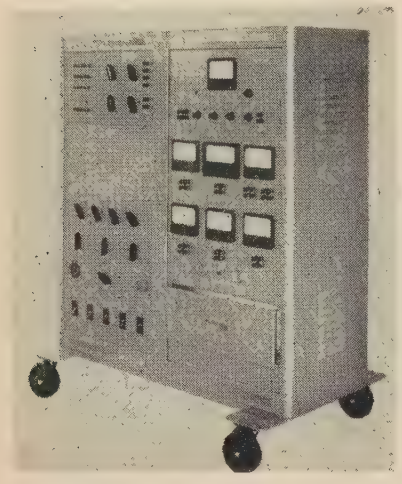
### TEST CONSOLE ground-checks missiles



The nominal 28-V dc output of the W-1400 portable inverter test console can operate any piece of aircraft or missile equipment up to 50 amps, says **Electrosolids Corp., Dept. S/A, 13745 Saticoy St., Panorama City, Calif.** Maximum voltage transients on the output of the power supply are under 20 per cent of the output voltage, and output currents are protected by breakers at ten, 30 and 50 amps.

A load bank section of the console can load inverters up to 750 va, three phase at 400 cycles, or 375 va, single phase at 800 cycles. Pushbutton switches are used to add or subtract loads to the device under test. The console is instrumented to monitor dc input, current, voltage and ripple, and ac current, voltage, power, distortion and phase rotation on each phase.

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### RECTIFIERS rated up to 16 amp

This series, designated Types X16RC2 through X16RC20 have been added to the line of "Thyrode" controlled rectifiers. The units are capable of controlling 16 amp of current on such applications of static switching, dc motor control, variable and regulated dc power supplies, welding control ignition firing and similar switching uses, says **International Rectifier Corp., Dept. S/A, 1521 E. Grand Ave., El Segundo, Calif.**

This three-junction semiconductor component, will switch rapidly to a conducting state either when a signal is applied to its third (gate) terminal, or when its critical breakover voltage is exceeded. All units are hermetically sealed and have an over-all height of 1.615 in. maximum.

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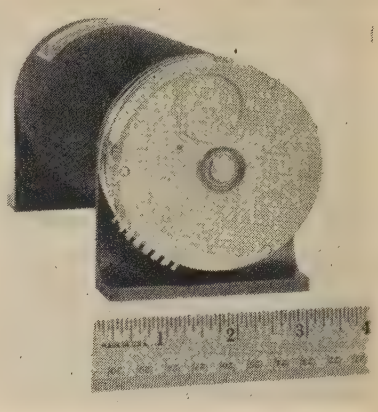
### A-D CONVERTERS are servo-operated



Known as the SBI-401 series, these units can perform from any dc signal input. The converters provide a full scale sensitivity of 10 MV and a response time, also for full scale of 2 sec., says **North Atlantic Industries, Inc., Instrumentation Div., Dept. S/A, 603 Main St. Westbury, N. Y.**

Measuring only 7 in. by 3 in., in its basic configuration, the unit can be readily adopted to meet application specifications because of its modular design.

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*more on page 264*


Taber

# TELEFLIGHT®

## MODEL 180

## AIRBORNE PRESSURE TRANSDUCER

Approximately 3½" long and 10 ounces in weight. The rugged construction of Model 180 makes it the ideal Transducer for airborne applications. BONDED STRAIN GAGE construction results in low sensitivity to vibration or shock in any axis. Proving ring acts as a heat-sink for the strain gages under zero gravity conditions. Resolution is INFINITE. Features standard built-in pressure overload protection. Pressure Ranges: 0-350, 0-750 and 0-1,000 PSI. Linearity 0.25%, Hysteresis 0.25% of F.S. at any given point, Ambient Temperature —100° F. to +275° F.

Write for literature on Miniature Transistor Amplifiers which were specially developed for missile and rocket applications.

*Write or telephone for literature and prices.*

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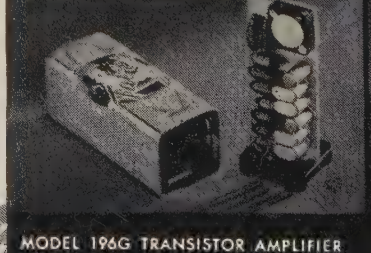

MODEL 196G TRANSISTOR AMPLIFIER

MODEL 214 TRANSISTOR AMPLIFIER

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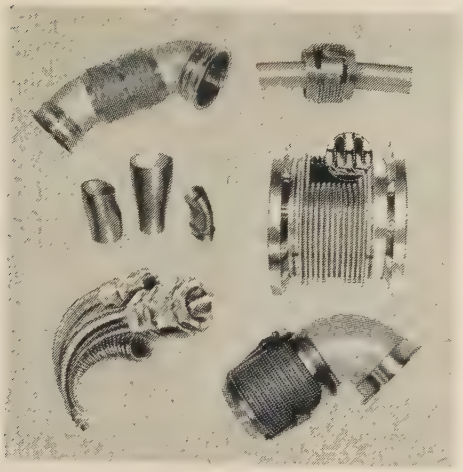
From the Ford Tri-motor to the Atlas-Centaur, Flexonics has been supplying components like these for the pioneer vehicles of air and space flight. Thin-wall



stainless steel tubing; ducting assemblies for bleed air, cooling and heating, cabin pressurization, anti-icing, exhausts, etc.; flexible ducting sections and joints; metal hose—all designed specifically for the aero/space industries and formed by exclusive methods to do more with less weight, in less space. Let the masters of precision-formed thin metals work with you on all your ducting requirements—both standard components and special engineering.

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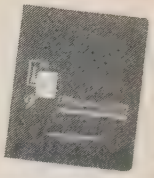

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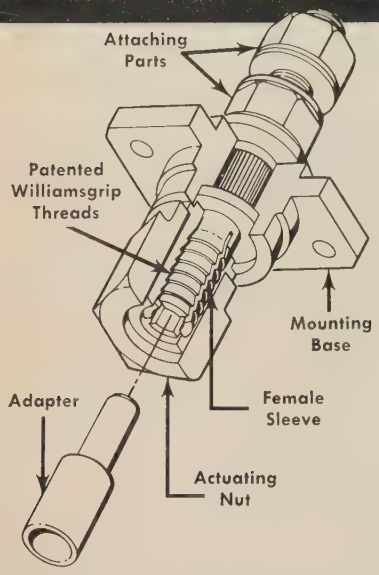
# WILLIAMSGRIP single circuit quick disconnect




**Williamsgrip electrical connectors** provide quick connect and disconnect with a flick of the wrist... plus full positive connection insuring maximum conductivity without the use of springs, slip joints or friction methods.

The patented Williamsgrip construction and special thread design prevents slippage and corrosion, resulting in cooler operation, greater reliability and longer life.

The self-wiping action of the connector eliminates arcing and excessive heating, and allows the connector to operate from 5° to 25°F cooler than the cable, even under conditions of 100 percent overload. Both connectors and adapters are constructed to withstand severe environmental conditions, and have successfully withstood temperatures over 2000°F.

These high current, single circuit connectors covering a wide range of wire and cable sizes have proved their reliability over more than a decade of versatile, rugged service for a wide variety of requirements in the military, industrial and commercial fields.

Write today for AiResearch Product Catalog on "Electrical Connectors."

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AiResearch Manufacturing Division

Los Angeles 45, California

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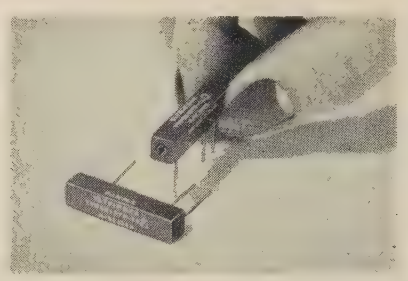
## POTENTIOMETER
### for printed circuit use



Ultrimmer, a unique new trimming potentiometer is able to withstand severe shock and vibration. They can be supplied for transistor circuitry with a high positive temperature coefficient. The units have a maximum temperature coefficient of 25 ppm per deg C, says **Ultronix, Inc., Dept. S/A, 111 E. 20th Ave., San Mateo, Calif.**

Another feature of the component is a special clutch arrangement which prevents overtravel or jamming of the slider and assures a positive starting grip on the positioning screw. They are available in rectangular case styles, measuring only ¼ x ¼ x 1¼ in. Ranges run from 200 to 150,000 ohms with zero end resistance and standard tolerances of +5 per cent.

Write in No. 352 on Reader Service Card

## LINEAR ACTUATOR
### has long stroke

An aircraft canopy linear actuator adaptable to a wide range of aircraft, missile, ordnance and industrial applications has been designed for a 300-lb normal load at 3.5 ips travel, says **Hoover Electric Co., Dept. S/A, 2100 S. Stoner Ave., Los Angeles 25, Calif.** The Model D-1870 actuator has a stroke of 31 in, operates on 28 V dc, and is available with trunnion type mountings, among others.

An electrical load sensing mechanism enables the device to sense, shut off and hold a predetermined load of 500 to 800 lbs. An electromagnetic clutch brake provides irreversability within the design load range to 1000 lbs in the current-off condition. The device breaks down into three major subassemblies for simplicity of service and replacement.

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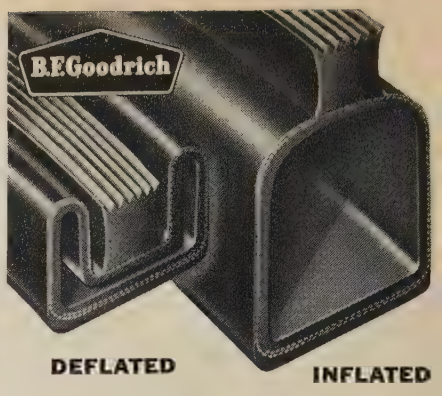
more on page 266


## Lightweight rubber seals inflate without stretching

B.F.Goodrich inflatable seals provide uniform sealing pressure, snap back into position when pressure is released. Use for sealing canopies, blast doors, access ports, etc. Ask your B.F.Goodrich representative to help solve your sealing problem.

**B.F.Goodrich**
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*Dept. SA-6, Akron, Ohio*

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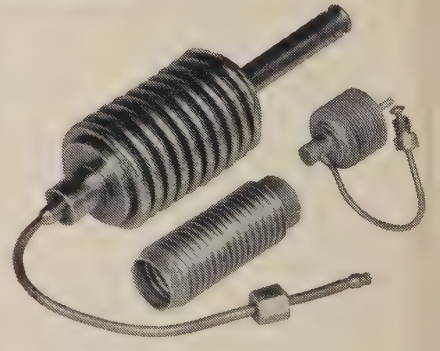

## Omega-design bellows for precision instrumentation

B.F.Goodrich now manufactures bellows and bellows assemblies to customer requirements. Convolutions shaped like the Greek letter Omega (Ω) equalize stress, result in extended service life. The design also improves accuracy, provides a more linear deflection output. Write for new brochure, "Seamless Bellows and Bellows Assemblies".

**B.F.Goodrich**
**aviation products**
*Dept. SA-6, Akron, Ohio*

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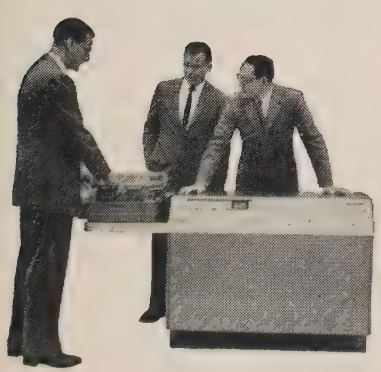
## This low-cost computer eliminates the "middleman" between the engineer's problem and answer!

Royal Precision

# LGP-30



Engineers in the aircraft and missile field get answers *fast* when they have direct access to the powerful LGP-30 electronic computer marketed by Royal McBee. Many are now solving such problems as wind tunnel and flight test data reduction, guidance system design, transducer calibrations, flutter and vibration studies, component reliability evaluations, specific impulse calculations and thermal stress distribution—*at desk-side!* Reason: this computer is programmed and operated by the engineer himself to cut through the maze of mathematical calculations demanded by today's complex aircraft design requirements.

The LGP-30 is low in cost – about the price of a good engineer – and is simple to program and operate. Its 4096-word memory is comparable to computers many times its size and cost. User-engineers develop a man-machine relationship to the point where it becomes an extension of their own thinking capacity. Bolder, more creative engineering almost always results.

No site preparation is necessary. Plug the LGP-30 into the nearest standard outlet and it is ready to go to work. Customers have access to an extensive library of programs and sub-routines—as well as an active users organization.

**Royal Precision Corporation**

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For information on the LGP-30 write **ROYAL McBEE CORPORATION**, data processing division, Port Chester, New York

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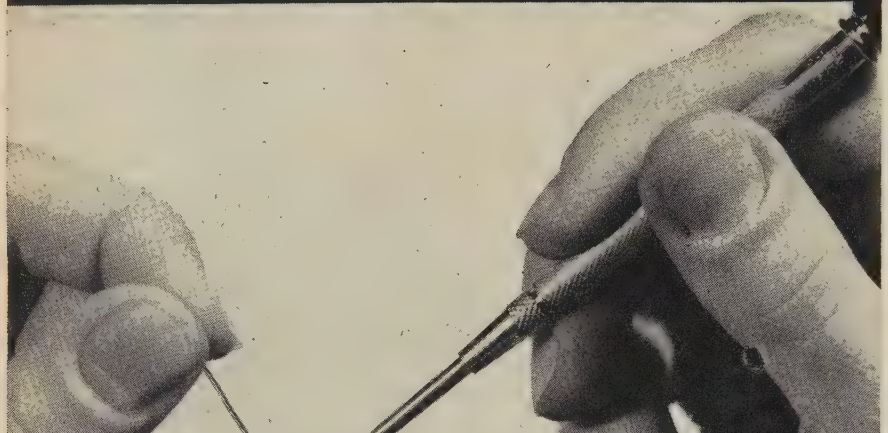
# FREE ANALYSIS
## OF YOUR SMALL METAL PARTS WELDING PROBLEMS



### 5400 Pigtails Assembled and Welded per Hour!

**PROBLEM:** join copper pigtails to brass resistor caps at highest possible rate, lowest possible cost, and with maximum production efficiency. The method previously used was mechanical staking which resulted in inferior joining.

**SOLUTION:** a Raytheon Welding Analyst recommended – and Raytheon designed and built – a fully automated precision welding system.

**RESULT:** pigtails welded at the rate of 5400 per hour, with consistently excellent electrical, electromechanical and environmental characteristics.

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If you have a small metal parts joining problem, see your Raytheon Welding Analyst. He will be happy to help you—without cost or obligation. Mail the coupon below for full details.

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**My problem is:** (describe metals, thicknesses, type of part, etc.)

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CITY_____ STATE_____

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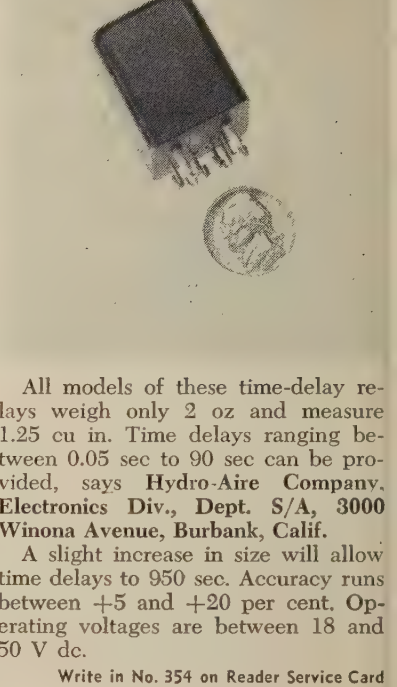
## *TIME-DELAY RELAYS are micro-miniature*



All models of these time-delay relays weigh only 2 oz and measure 1.25 cu in. Time delays ranging between 0.05 sec to 90 sec can be provided, says **Hydro-Aire Company, Electronics Div., Dept. S/A, 3000 Winona Avenue, Burburbank, Calif.**

A slight increase in size will allow time delays to 950 sec. Accuracy runs between +5 and +20 per cent. Operating voltages are between 18 and 50 V dc.

Write in No. 354 on Reader Service Card

## *ANALOG-DIGITAL CONVERTER is servo-controlled*

Type A1503-11, a servoed ad converter consists of an amplifier, servo motor or tachometer generator, an ad converter and appropriate gearing. They may be read either "on the run" or "on demand" says **Kearfott Co., Inc., Dept. S/A, 1500 Main Ave, Clifton N. J.**

Contacts and brushes for each binary bit are capable of carrying a load current of 20 ma at 10 V dc.

Write in No. 355 on Reader Service Card

*more on page 268*



**Write in No. 255 on Reader Service Card**

# 20 Reasons

for using Hadley cryogenic fluid controls in new hydrogen super-thrust missiles

Nineteen of the reasons are the proven performance of Hadley valves and regulators —many of which operate under cryogenic conditions—at nineteen key control points on the Atlas ICBM. It's as tough a task of pressure regulation as has yet come along.

For instance—the main regulatory and relief valves for the LOX tank must accurately control a widely varying flow rate of hard-to-contain helium under a temperature span of 550°F.

20 Demonstrated control capability in cryogenic and other conditions—combined with precise fabrication, extensive in-plant development testing and continual applied research—means that Hadley is uniquely able to assist in developing pressure system specifications for new liquid hydrogen systems. If your concern is fluid control at low temperature with high reliability, check Hadley first. Write for Information File SA-1095-1.

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PIONEERING IS OUR BUSINESS

Bendix 10-liter liquid oxygen converter meets MIL-C-19803, "Type I" specifications.

*Supplying the breath of life at 80,000 feet...*

# BENDIX LOX CONVERTERS MEET NEW NAVY STANDARDS

Bendix*—pioneer in the development of airborne liquid oxygen systems—is now producing lox converters for several high-performance U. S. Navy aircraft.

The Bendix 29067-A1 10-liter converter complies with all requirements of MIL-C-19803, "Type I." Bendix design innovations meet the latest USN BuWeps "quick turn around" concept.

Both the 10-liter converter and the 5-liter converter meeting MIL-C-19328 requirements are self-contained units. In operational aircraft, empties can be removed and replaced by filled units in three minutes or less by using quick vent and supply line disconnect fittings.

Easy to operate, and dependable in vital jobs, these converters are products of specialized Bendix skill and experience. For more than a quarter century, Bendix has been a major producer of airborne oxygen equipment for military, commercial and private aircraft. This experience may be applicable to *your* oxygen needs. Write for complete information today. *TRADEMARK

Bendix 5-liter lox converter and aircraft mounting tray featuring single point tie-down.

Pioneer-Central Division
HICKORY GROVE ROAD
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THE Bendix CORPORATION

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## FREQUENCY GENERATORS for airborne applications

Type T, a line of frequency resonators and frequency standards, uses a unique system of internal shock mounts. This system permits operation of the units at shock loads as high as 150 g's says **Gyrex Corp., Dept. S/A, 3003 Pennsylvania Ave, Santa Monica, Calif.**

Performance in vibration environments as severe as 20 g's at 2 Kcps is assured. Hermetically sealed, the instruments have been tested over a wide range of MIL-E-5272A conditions.

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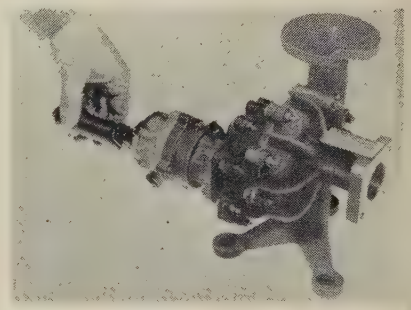
## PUMP is rugged



This water-injection pump can handle 35 gpm of water and will withstand dry running for most of its operating life, says **Santa Barbara Div., Curtiss-Wright Corp., Dept. S/A, 6767 Hollister Ave., Goleta, Calif.** Minimum discharge pressure is 250 psig, and excessive chemicals or minerals in the water will not harm the rugged pump.

The Model 188 was designed for use in connection with turbojet engines, and it has an impeller configuration that simplifies modification problems. Hydraulic power supply is 7.4 gpm, at 2650-psig inlet pressure with motor discharge pressures to 150 psig. The pump is adaptable to turbine, electric motor or engine accessory pad drive.

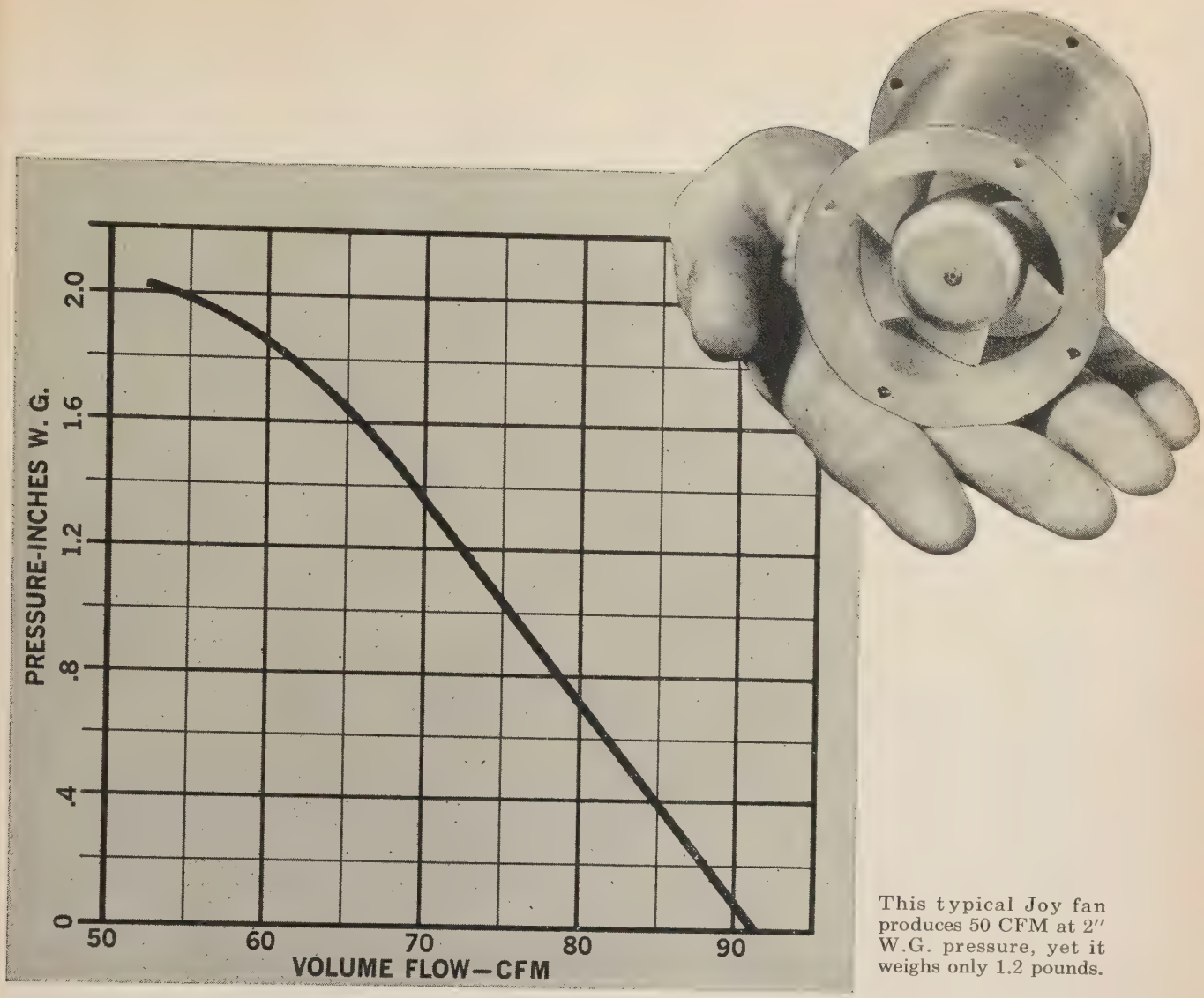
Write in No. 357 on Reader Service Card

## TRIMMER takes little space

The Comp-U-Trim Model F wire wound linear trimming potentiometer uses the smallest mounting area of any comparable component, according to **Eastern Precision Resistor Corp., Dept. S/A, 675 Barbey St., Brooklyn 7, N.Y.** The unit may be mounted on the front panel or under the chassis.

Resistance ranges extend from ten to 50,000 ohms, with plus or minus ten per cent tolerances. Power rating is .75 W at 85 deg C and .5 W at 125 deg C. The Model F has a ⅝-in dia, and the housing is made of aluminum.

Write in No. 358 on Reader Service Card




This typical Joy fan produces 50 CFM at 2″ W.G. pressure, yet it weighs only 1.2 pounds.

## *Joy Design Means:*

# HIGHEST OUTPUT PER POUND OF FAN

Joy aircraft and electric fans are designed to provide maximum CFM per pound of fan. The inherent high efficiency of the basic vaneaxial design, with the motor mounted inside the fan, has made Joy fans standard wherever weight or size is a critical consideration.

Joy fans meet Mil Specs, and have been accepted for both airborne and ground installations. RCA, Boeing, Douglas, Goodyear, Motorola, Lockheed, and Raytheon are just a few of the firms incorporating Joy fans in their products.

Over 340 standard models are available, and custom design can be supplied to meet your special requirements. For complete information on how compact, efficient Joy fans can solve your design problems, write for Bulletin 927-38.

**AIR MOVING EQUIPMENT FOR ALL INDUSTRY**

**JOY**

**Joy Manufacturing Company**
**Oliver Building, Pittsburgh 22, Pa.**

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

**Write in No. 257 on Reader Service Card at start of Product Preview Section**

# data preview

**WAVE ANALYZER**—The use of automatic wave analyzer systems for measuring and charting many types of complex waves are the subject of Bulletin DB 9050a, a 16-page report issued by **Industrial Systems Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, 10721 Hanna St., Beltsville, Md.** The bulletin includes information on the relation of magnetic tape recorder, playback loop transport, and wave analyzer.

Write in No. 359 on Reader Service Card

**TEST CHAMBERS** — "Simulating Space," a six-page article on the use of land-locked chambers to establish missile environments for equipment testing, has been issued by **Hudson Bay Co., Dept. S/A, 3070-82 W. Grand Ave., Chicago 23, Ill.** Sound as a mechanical force, temperature, humidity, acceleration, and volatile atmospheres are among the factors considered

Write in No. 360 on Reader Service Card

**TUBING & DUCT JOINTS**—A design information catalog, No. 800, for aircraft and missile tubing and duct joints has been issued by **Aeroquip Corp., Marman Div., Dept. S/A, 11214 Exposition Blvd., Los Angeles, Calif.** It contains design data and production information on joints suitable for temperatures and pressures for gaseous, liquid and air systems, as well as couplings for fastening and sealing applications.

Write in No. 361 on Reader Service Card

**TOGGLE SWITCHES**—The 32-page catalog 73d, which covers a variety of high-performance toggle switches and toggle switch assemblies for airborne, electronic and other applications, is available from **Micro Switch Div., Minneapolis-Honeywell Dept. S/A, Freeport, Ill.** Pull-to-unlock, electrical memory, rocker-actuated and miniaturized designs, along with military versions, are described.

Write in No. 362 on Reader Service Card

**BEARINGS** — Engineering and purchasing personnel may obtain this 140-page publication, "Design and Purchasing Manual," on miniature and instrument ball bearings from **New Hampshire Ball Bearings, Inc., Dept. S/A, Route 202, Peterborough, N.H.** The manual contains specifications on 370 standard bearings from 1/10 to 5/8 in od, along with 22 engineering bulletins on bearing life and operation.

Write in No. 363 on Reader Service Card

**LAB STANDARDS**—Electrical instruments that serve as laboratory standards for the calibration of working equipment in the aircraft and missile development fields and standards laboratories have been described in a 24-page brochure released by **Weston Instruments Div., Daystrom, Inc., Dept. S/A, 64 Freylinghuysen Ave., Newark 12, N.J.** "World Standards" includes details and diagrams of voltmeters, ammeters, wattmeters, and current transformers, as well as on other equipment

Write in No. 364 on Reader Service Card

**ELECTROFORMING**—Current uses for electroforming are discussed in a manual for designers, engineers and manufacturers issued by **Allied Record Mfg. Co., Research & Engineering Div., Dept. S/A, 6916 Santa Monica Blvd., Los Angeles 38, Calif.** It contains the latest technical information, charts and tables of engineering data.

Write in No. 365 on Reader Service Card

**SPACE PHOTOGRAPHY**—Stills from the four space films obtained as a result of a space-photography project have been included in Bulletin PIB-38, available from **Missile & Space Vehicle Dept., General Electric Co, S/A, 3198 Chestnut St, Philadelphia 4, Pa.** The 12-page publication includes a two-page mosaic made from films taken from an Atlas missile, and it also covers camera system design.

Write in No. 366 on Reader Service Card

**GEAR CASE ACCESSORIES** — The "Tedeco Aviation Grade Gear Case Accessories" catalog is a 24-page publication featuring full scale, dimensional drawings of the products of **Technical Development Co., Dept. S/A, 305 S. Chester Pike, Glenolden, Pa.** Complete specifications are provided for self- closing magnetic drain plugs, fill and drain hoses, sight glasses, breather vents, and other components.

Write in No. 367 on Reader Service Card

**RE-ENTRY & RECOVERY**—Two booklets on the re-entry and recovery systems for two missile programs have been released by **Missile & Space Vehicle Dept., General Electric Co., Dept. S/A, 3198 Chestnut St., Philadelphia 4, Pa.** PIB-20 and PIB-23 offer details on the Thor-Able and the Atlas GE-RVX-2, and the Atlas bulletin also summarizes the overall re-entry-recovery program with ablating-type vehicles.

Write in No. 368 on Reader Service Card

**THERMAL INSULATIONS**—Thermal insulations for all types of commercial and industrial requirements, in applications ranging from —400 deg F to 3000 deg F, are described in catalog IN-244A prepared by **Johns-Manville Sales Corp., Dept. S/A, 22 E. 40th St., New York 16, N. Y.** It contains application photos, descriptions, available forms or types, advantages, and detailed specification data, including compliance with government specifications and ASTM standards.

Write in No. 369 on Reader Service Card

**OPTICAL TRACKING**—A brochure describing its recording optical tracking instrument for missile tracking has been prepared by **Perkin-Elmer Corp., Dept. S/A, Norwalk, Conn.** It discusses operational features and specifications, and illustrates the resolution obtainable with the system.

Write in No. 370 on Reader Service Card

**FACILITIES**—Production and quality control techniques for the manufacture of pressure, temperature and speed measurement devices, among others, which are useful under supersonic flight conditions, have been described in a facilities report prepared by **Consolidated Controls Corp., Dept. S/A, Bethel, Conn.** The eight-page booklet also outlines management and engineering policies.

Write in No. 371 on Reader Service Card

**PRINTED CIRCUITS**—Printed circuits are discussed in bulletin 1159 issued by **Whitney Blake Co., Dept. S/A, New Haven 14, Conn.** It discusses types of insulating materials and the current capacity in relation to width of copper conductive pattern, types of plating, and recommendations covering materials available for switch and contact patterns.

Write in No. 372 on Reader Service Card

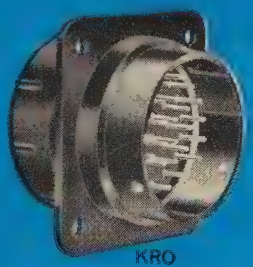
**PUMPS**—Design details and operating characteristics of a complete line of hydraulic pumps, fluid motors and valves have been offered in a 72-page catalog issued by **Denison Engineering Div., American Brake Shoe Co., Dept. S/A, 1160 Dublin Rd., Columbus, O.** Bulletin 220 contains special sections on axial- and vane-type hydraulic pumps, axial- and vane-type fluid motors, four-way directional control valves, surge damping valves, and other control devices.

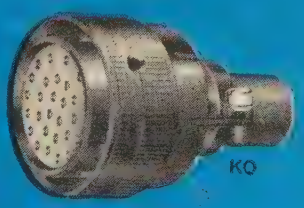
Write in No. 373 on Reader Service Card

*more on page 272*

# EXCLU-SIVELY FROM CANNON

• MOISTURE PROOF

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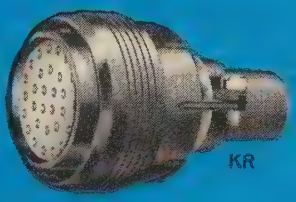



**A MINIATURE GENERAL PURPOSE PLUG FEATURING ONE RECEPTACLE TO ACCEPT EITHER BALL OR BAYONET LOCK PLUG... WITH HIGH ALTITUDE PERFORMANCE**—Now you can get true high-altitude performance in a miniature general purpose plug! Plus, Cannon's KQ/KR *exclusively* provides one receptacle to accept either ball or bayonet lock coupling device. The KQ/KR is the latest Cannon contribution in miniature plugs... crimp-type snap-in contacts... probe-proof socket contacts... moisture sealing grommet... field service with a simple hand tool! The KQ/KR is another reason why you should consult the first name in plugs—why you should always consult Cannon for *all* your plug requirements. Write for further information on the KQ/KR, or any Cannon product.

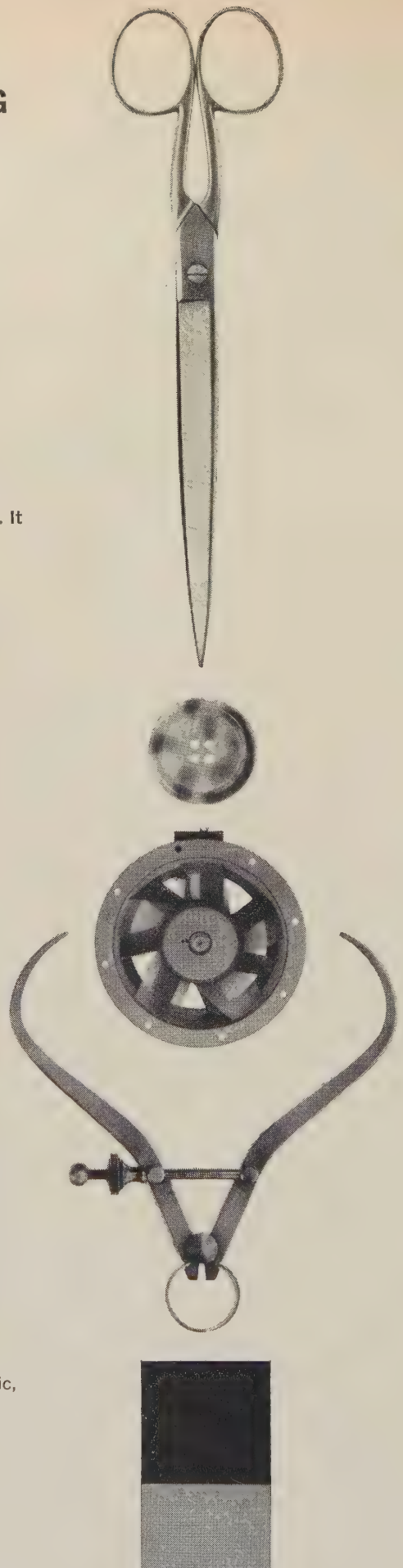
**CANNON PLUGS**

**CANNON ELECTRIC COMPANY,** 3208 Humboldt St., Los Angeles 31, Calif.

Write in No. 258 on Reader Service Card at start of Product Preview Section

# EFFICIENT AIR MOVING UNITS ARE 'TAILOR MADE'

There's a highly advanced technology to the business of moving air efficiently, quietly, to precise requirements. It takes, for instance, upward of a million-dollar investment in laboratory, testing and instrumentation, in addition to development and design capabilities to tailor the **right** solution of the problem to the **total** systems requirement. That's the kind of capability Torrington has. And that's why Torrington is the world's finest in the application of the specialized "science"* of creating air moving units for the full range of electronic, airborne and military applications. Cooling thought for the day: Keep the name in mind.



**THE TORRINGTON MANUFACTURING COMPANY**

**SPECIALTY BLOWER DIVISION** Torrington, Connecticut

*A branch of study concerned with the observation and classification of facts.—Webster

Write in No. 259 on Reader Service


## DATA PREVIEW

**FACILITIES**—Non-destructive test instruments, airframe and missile production machinery, and gas analyzing units are among the diverse products produced by **Pioneer Industries, Dept. S/A, 3455 W. Vickery, Forth Worth, Texas.** An eight-page brochure outlines the company's capabilities in research and development, as well as in manufacturing.

Write in No. 374 on Reader Service Card

**SIGNAL GENERATORS**—A 28-page book containing complete specifications and prices of 152 signal generators manufactured by 30 American and foreign companies is available at $2.00 by writing **Technical Information Corp., Dept. S/A, 41 Union Square, New York 3, N.Y.**

Write in No. 375 on Reader Service Card

**THERMAL SYSTEMS**—A 4-page sheet describes all wet and dry bulb thermal system components bulbs, tubing and accessories, which are used with Brown filled-system thermometer-psychrometers. It is available from **Minneapolis-Honeywell Regulator Co., Industrial Div., Dept. S/A, Wayne & Windrim Aves., Philadelphia 44, Pa.**

Write in No. 376 on Reader Service Card

**RESISTORS**—This 24 page engineering data book is filled with charts, diagrams and data of particular interest to engineers concerned with the application of precision wire wound and composition variable resistors. It can be secured by writing directly to the manufacturer, **Reon Resistor Corp., Dept. S/A, 155 Saw Mill River Rd., Yonkers, N.Y.**

Write in No. 377 on Reader Service Card

**VALVES & FITTINGS** — Standard valve and fittings for 30,000 and 60,000-psi service in research and pilot plant testing are described in the 16-page Catalog 659 by **High Pressure Equipment Co., Inc., Dept. S/A, Erie, Pa.** Dimensional data, cross-sectional drawings and tubing sizes are presented for thirty-two valves and fittings, including adapters, tees, crosses, and safety head assemblies.

Write in No. 378 on Reader Service Card

**ROTARY SWITCHES**—A new line of rotary switches for computer control consoles that introduce information by coverting decimal constants to a positional number code has been detailed in data Sheet 170 by **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill.** The switches are available with eight to ten detented positions and three, four, six or eight plastic enclosed basic switches.

Write in No. 379 on Reader Service Card

*more on page 274*

# Some Ideas

for your file of practical information on drafting and reproduction from

**KEUFFEL & ESSER CO.**

This badly-soiled drawing is getting a mild soap-and-water bath to restore its original printing quality.

Tracings you can wash! Mention this to a Chief Draftsman and you'd likely see his eyes light up as he perceives the implications of a simple new technique – one that's being used now by Raytheon Co. and could save them at least $50,000 this year. The secret: Herculene® Drafting Film by K&E, plus Staedtler Duralar plastic pencils –a completely washable combination, and the answer to . . .

### A Dirty Old Problem

Functionally, an engineering drawing is only as good as the prints it will produce. This is a fact of life that governs any distribution-print system – conventional blueprints, white prints, or reduced-size prints. It holds true in a full-fledged miniaturization program, too. How long will an original tracing continue to produce top-notch prints? The answer depends on how much and what kind of handling it receives. Revisions, smudging, processing and filing all take their toll of a drawing's printability, decreasing it gradually – and sometimes quite sharply. As printing quality diminishes, some form of rehabilitation becomes necessary. But re-drawing – whether manual or photographic – can be costly and time-consuming. Drafting and reproduction experts have been wishing and working for a more efficient and economical solution.

### A Simple Solution: Soap-and-Water

Washing became a possible answer with the advent of polyester-base drafting films and plastic pencils – and a practical reality with Herculene. This remarkable film combines a stable, waterproof Mylar® base with a completely washable surface for smudge-proof Duralar pencil lines – which *bond* to the Herculene surface and won't wash off.

Only the dirt washes away. There's no loss of line-background contrast, no loss of detail. The tracing can be restored to its original condition in a few moments – without re-drawing!

### A Proved Money-Saver

To amplify an earlier point: the Missile Systems Division of Raytheon has been washing Herculene drawings for the past year, and now expects to save over $50,000 on re-draws alone in the year ahead. A large aircraft manufacturer has used the Herculene-Duralar soap-and-water method even longer, and reports impressive dollar savings plus an outstanding improvement in print quality.

In 6 months of testing and 14 months of actual drafting-room use, Raytheon engineers exposed Herculene to all basic trials – and a battery of fiendishly extreme conditions. They scored Herculene with a sharp scriber, but couldn't remove the matte surface. They taped a sheet to the floor and had a 200 pounder roll over it in a swivel chair during an active day. Herculene was baked and frozen – and doused with hot coffee – with no effect on its surface. After two hours, the coffee stain was washed off without a trace. Results of these torturous tests were so favorable that now, Raytheon's Missile Systems Division uses practically no drafting film *but* Herculene!

### A Note of Caution

There are other waterproof drafting films, but plastic pencil lines will wash off some of them. So, when comparing polyester-base films, it's best to check them for *pencil line washability*. And another point – don't try this technique with ink or graphite lines – use only the Duralar K1 or K2. Even if you don't want to adopt the washing technique immediately, you're free to make the change at any time if you use Herculene – the *indestructible* drafting medium with the washable, engineered surface.

### More Merciless Testing Invited

We'd be pleased to send you a sample of Herculene, and we invite you to do your best to ruin its excellent drafting and printing quality. The Herculene sheet comes in a small folder with complete instructions and a water-fast Duralar pencil – which K&E engineers helped develop for use with washable Herculene Drafting Film. Mail the coupon below for your sample!

**KEUFFEL & ESSER CO.,** Dept. AA-6 Hoboken, N. J.

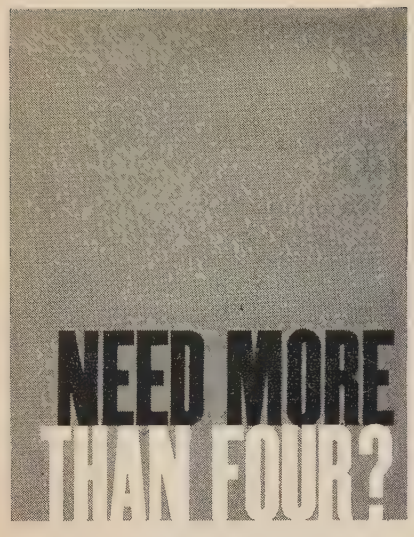
Please send me further information about the washable tracing method, plus a sample sheet of Herculene Drafting Film and a Duralar pencil.

Name & Title_____

Company & Address_____

_____ 1509

**Write in No. 260 on Reader Service Card at start of Product Preview Section**




## Only Voltmeter with the Factual Fifth Figure

**WHEN FOUR-DIGIT ACCURACY JUST ISN'T ENOUGH,** specify the five-digit NLS V35 — world's most accurate digital voltmeter. Only the V35 gives you the "factual fifth figure" . . . full five-digit resolution of 0.001%. Here is the instrument for your measuring jobs demanding maximum accuracy — automatic missile checkout, readout and printout in data logging and computer systems, critical production inspection. Only the V35 offers you the benefits of "no-needless-nines" logic — greater reliability, increased speed, longer parts life. Contact NLS today for the full story.

V35 Specifications: Measures DC voltage from ±0.0001 to ±999.99; DC voltage ratio from ±00.001% to ±99.999% . . . DC voltage accuracy is ±0.01% of reading or ±1 digit . . . overall accuracy for voltage ratio is ±0.005% of reading or ±1 digit . . . "factual fifth figure" — 0.001% resolution . . . transistorized "no-needless-nines" logic . . . plug-in modular construction . . . simple external connections for AC/DC converter, pre-amplifier and data logging accessories . . . one-package design — 5¼" high — for standard rack mount . . . automatic selection and indication of range and polarity . . . interchangeable plug-in stepping switch-resistor assemblies sealed in oil . . . $3,750.00, complete. Available in four-digit model for $3,150.00, complete.

NLS *Originator of the Digital Voltmeter*

**non-linear systems, inc.**
DEL MAR (SAN DIEGO), CALIFORNIA

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## DATA PREVIEW

**CONNECTORS** — Printed circuit connectors are described in a catalog, Form No. PC-11-59, by **Burndy Corp., Buggie Div., Dept. S/A, Toledo 1, Ohio.** It contains design and engineering data for standard card receptacles, terminal strips, contact strips, and miniature series coaxial connectors.

Write in No. 380 on Reader Service Card

**STATIC INVERTER**—Bulletin S-1035 describes static inverter model SIS 3-40613 of **Magnetic Amplifiers, Inc., Dept. S/A, 632 Tinton Ave., New York 55, N. Y.** It contains functional description, diagrams, and engineering specifications.

Write in No. 381 on Reader Service Card

**SEALING ALLOYS** — Technical data, graphs, and properties of gas-to-metal sealing alloys are contained in a bulletin issued by **Wilbur B. Driver Co., Dept. S/A, 1875 McCarter Hwy., Newark 4, N. J.** The hermetic sealing process is described.

Write in No. 382 on Reader Service Card

**PUMPS**—A new series of two-stage, leak-proof "canned" pumps for heads up to 600 ft has been described in the four-page Bulletin 1080 by **Chempump Div., Fostoria Corp., Dept. S/A, P.O. Box 35-2, Huntingdon Valley, Pa.** The Chempump units are suitable for handling fluids at pressures to 3500 psi.

Write in No. 383 on Reader Service Card

**FASTENERS**—High-pressure, vibration-resistant seals and fasteners are described in a catalog, No. 359A, issued by **A.P.M. Corp., Dept. S/A, 252 Hawthorne Ave., Yonkers, N. Y.** It includes tabular data, military and commercial specifications, engineering drawings, and allied information.

Write in No. 384 on Reader Service Card

**JET STARTER**—The type 36E59 air turbine starter and accessory drive unit is designed to minimize accessory location problems, according to Publication 36U-6-91A issued by **Utica Div., Bendix Aviation Corp., Dept. S/A, 211 Seward Ave., Utica, N.Y.** The starter features an integral mounting pad for a continuous drive.

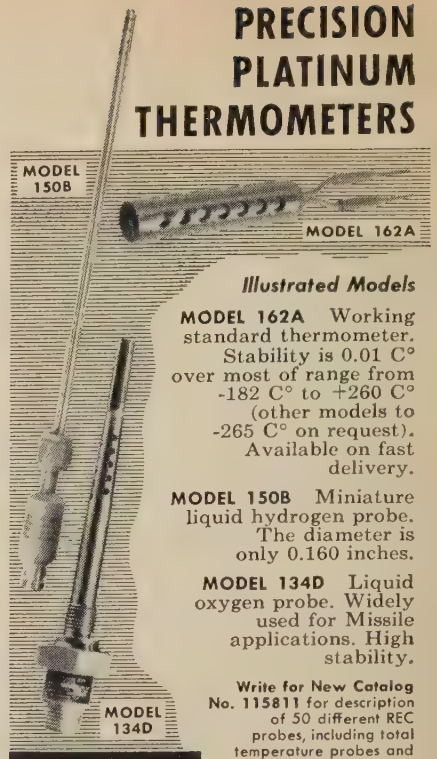
Write in No. 385 on Reader Service Card

**RELAY**—The BR-1SZ miniature relay, a 1¼-oz unit described in Technical Bulletin BR-593, requires only five mw for operation in airborne and ground use, according to **Babcock Relays, Inc., Dept. S/A, 1640 Monrovia Ave., Costa Mesa, Calif.** The sealed unit is designed for long life and a —65 to +125 deg C temperature range in applications requiring very critical pull-in to drop-out ratios.

Write in No. 386 on Reader Service Card

*more on page 276*


## PRECISION PLATINUM THERMOMETERS




*Illustrated Models*

**MODEL 162A** Working standard thermometer. Stability is 0.01 C° over most of range from -182 C° to +260 C° (other models to -265 C° on request). Available on fast delivery.

**MODEL 150B** Miniature liquid hydrogen probe. The diameter is only 0.160 inches.

**MODEL 134D** Liquid oxygen probe. Widely used for Missile applications. High stability.

Write for New Catalog No. 115811 for description of 50 different REC probes, including total temperature probes and surface probes.

REC **ROSEMOUNT ENGINEERING COMPANY**
4902 West 78th St.
Minneapolis 24, Minn.

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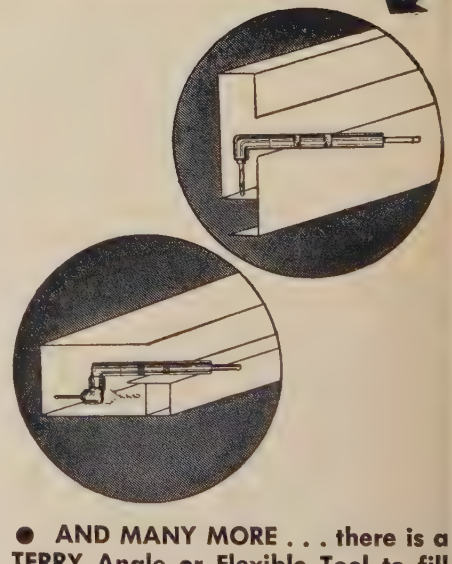
## . . . FOR THESE ANGLE DRILLING APPLICATIONS



● **AND MANY MORE . . . there is a TERRY Angle or Flexible Tool to fill your needs.**

TERRY Angle Drilling Attachments

Folder on request

**GEORGE A. TERRY CO.**
354 S. Elmwood Ave., Buffalo 1, N. Y.

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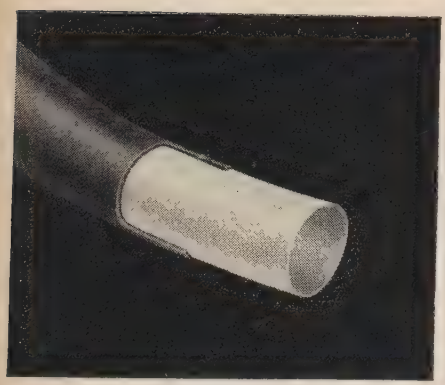
Missile hydraulic system uses hose lined with TEFLON to insure the utmost reliability of performance.

# For reliability under the toughest air-borne conditions: specify hose lined with TEFLON®



In air-borne applications, which put a premium on maximum reliability and space savings, the use of hose lined with TEFLON fluorocarbon resins insures trouble-free performance and often permits the use of smaller-diameter hose to handle the high pressures involved.

In missiles, for example, hydraulic and auxiliary power systems are equipped with hose lined with TEFLON. TEFLON resins are inert to virtually all chemicals and solvents encountered, and they offer exceptional durability under flexing, including torque stress and vibration. TEFLON TFE resins are rated for continuous use up to 500°F.

It will pay you to find out more about the extra safety and dependability and the more efficient design made possible by hose lined with TEFLON. For more information about properties and available varieties of this type of hose, consult your hose supplier or write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept. T-6-6, Room 2526, Nemours Building, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

DU PONT REG. U.S. PAT. OFF. **TEFLON®** FLUOROCARBON RESINS

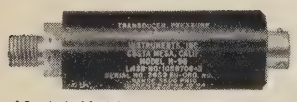
BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

*TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resin.*

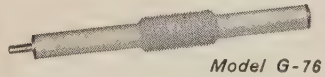
**Write in No. 264 on Reader Service Card at start of Product Preview Section**

FROM
SERVONIC...
*A complete line of Transducers for Rugged Applications*

**Model H—High Pressure Transducers:** For highly accurate measurement of pressure in corrosive fluids while exposed to extreme environments. Sealed, oil-filled cases available in most models. 400 to 8,000 psi. Vibrations to 30g. Various case configurations readily available. Write for Bulletin SI-581.



*Model H-90*



*Model G-76*

*Model L-44*

**Model G—Rectilinear Potentiometers:** For measuring displacement of missile and aircraft. actuators. Can be mounted internally or externally. Vibration levels to 35g. Ranges from 1/8" to 12". Critical elements of this high performance potentiometer are humidity sealed within a high-strength alloy case.

**Model L—Low Pressure Transducers:** Rugged, high response instrument. Pressure actuated, corrosion resistant aneroid elements operate precision potentiometer. Switching function can be accomplished in lieu of potentiometer output. Working fluids excluded from sealed oil-filled case. Send for Bulletin SI-582.

*Special designs to your specifications.*

SERVONIC
INSTRUMENTS, INC.
640 Terminal Way, Costa Mesa, California

**Write in No. 265 on Reader Service Card**



## DATA PREVIEW

**CIRCUIT BREAKERS** — What is reported to be the electrical industry's most complete and diversified line of molded-case circuit breakers available is described in a 40-page bulletin prepared by **I-T-E Circuit Breaker Co., Dept. S/A, 1900 Hamilton St., Philadelphia 30, Pa.** Bulletin 5001-1A offers ratings, specifications, and operating characteristics.

Write in No. 435 on Reader Service Card

**TEST LAB**—An environmental test laboratory capable of performing military and commercial testing of electronic equipment has been described in a ten-page brochure by **Stavid Engineering, Inc., Dept. S/A, Plainfield, N.J.** Tests include those for pressure, temperature, shock and vibration, altitude, and electronic radiation, among others.

Write in No. 387 on Reader Service Card

**FLEXIBILE SHAFT**—Over 180 variations of flexible shaft assemblies have been included in Form 574, an eight-page catalog prepared by **F. W. Stewart Corp., Dept. S/A, 4311-13 Ravenswood Ave., Chicago 13, Ill.** The standard assemblies contribute to economy of time and expense because they are assembled from stock components.

Write in No. 388 on Reader Service Card

**SWITCHES** — A line of electrical switches and quick-connect terminals has been described in a 20-page catalog available from **Ark-Les Switch Corp., Dept. S/A, 51 Water St., Watertown, Mass.** Switches covered include multi-circuit, motor reversing, rotary stack, pushbutton and slide types.

Write in No. 389 on Reader Service Card

**BERYLLIUM**—A pictorial description of the design and fabrication of beryllium heat-sinks is contained in a booklet by **Brush Beryllium Co., Dept. S/A, 5209 Euclid Ave., Cleveland 3, Ohio.** It is called "Beryllium in Project Mercury."

Write in No. 390 on Reader Service Card

**STEPPER MOTORS**—A technical brochure, SP9-1, describes stepper motors and pulsed stepping devices. It has been prepared by the **A. W. Haydon Co., Dept. S/A, 232 No. Elm St., Waterbury, Conn.** It contains schematic drawings of application circuitry, pulse profiles, and construction details.

Write in No. 391 on Reader Service Card

**POTENTIOMETER**—A 16-page certified test report of particular interest to engineers with trimming potentiometer applications is now available from **Helipot Division, Beckman Instruments, Inc., Dept. S/A, Fullerton, Calif.**

Write in No. 392 on Reader Service Card

*more on page 278*

SELECTIVE PLATING
with the DALIC PROCESS

*Precision-plating a roller.*

FOR QUICK PRECISION PLATING

1 Building-up worn or over-machined parts to exact size.
2 Plating isolated sections—saves extensive masking.
3 Fitting bearings to close tolerances.
4 Selective stopping-off prior to carburizing or nitriding.

**No Immersion Tanks. Mobile Equipment.**

With a Dalic power pack, plating tools and solutions you can plate many jobs quicker at lower cost than with stopping-off and bath plating. Deposits accurately controlled. Use anywhere in your shop.

**Dalic Plating Solutions**

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*A Subsidiary of*
The Steel Improvement & Forge Co.

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153 East 26th Street
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OHIO METACHEMICAL, INC.
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Amchem points the way...

# ALODINE 1200S

## a new surface conversion treatment for aircraft aluminum!

If you are producing aluminum for aircraft fabrication, investigate the production advantages of Alodine 1200S—the new conversion coating that provides constant, uniform quality as well as big savings in time, equipment and processing costs!

Through increased chemical activity Alodine 1200S slashes processing time up to 50 percent! A 1200 system can be installed on your production line quickly and conveniently . . . and bath is maintained chemically . . . no special equipment required to control contamination. In an Alodine 1200S system, products can be processed through dip in the same time cycle other conversion coatings require for continuous spray lines. One processor is now using Alodine 1200S in a 45- to 60-second treating cycle compared with a former process which took six minutes—and he's doing it with no increase or revision in existing processing facilities!

Protect your aircraft aluminum fabrications best, at less cost, in less time with Alodine 1200S—qualified under Government Specification MIL-C-5541.

**Passed with flying colors!**

The first major aircraft manufacturer has successfully completed rigorous testing procedures on Alodine 1200S and reports complete satisfaction of its many advantages in aircraft processing of aluminum. Write for details today!

AMCHEM ALODINE 1200S

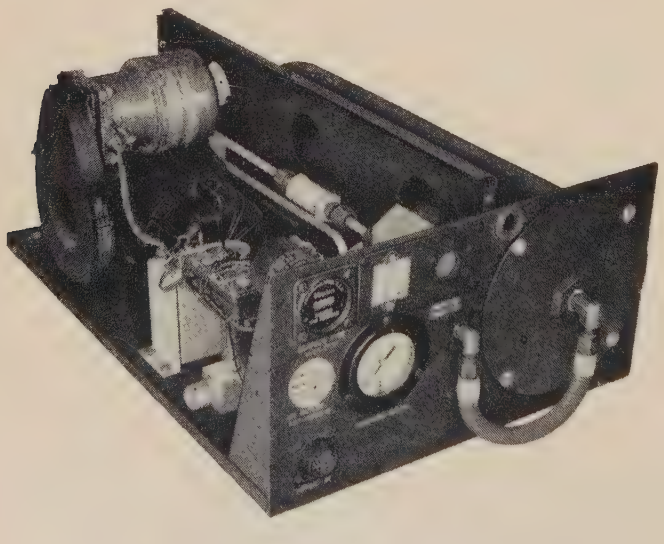
Amchem and Alodine are registered trademarks of AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)
AMBLER, PA. • Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont.

**Write in No. 267 on Reader Service Card at start of Product Preview Section**

*FILLING A GAP AT HIGH ALTITUDES! Proper atmospheric environment must be maintained under varying conditions for reliable functioning of modern electronic systems. This Budd Lewyt unit automatically maintains constant air pressure at low relative humidity for an air-borne counter-measure system over a wide range of altitude, temperature, and humidity. Yet it weighs only 25 pounds. Data sheet on Model 4010 will give you complete information. Designs are available for a wide variety of space applications in static or regenerative types. Write Environmental Control Section, Dept. 26, Budd Lewyt Electronics, Inc., Long Island City 1, N. Y.*

**BUDD LEWYT** A SUBSIDIARY OF THE Budd COMPANY

HEAT EXCHANGERS • AIR CONDITIONERS • PRESSURIZERS • DEHYDRATORS
FOR GROUND, SHIPBOARD AND SPACE APPLICATIONS



Write in No. 268 on Reader Service Card at start of Product Preview Section


## DATA PREVIEW

**FACILITIES**—The manufacturing and engineering facilities are described in a brochure, Form No. D-1702, issued by **H. W. Tuttle & Co., Dept. S/A, Tecumseh, Michigan.** It illustrates its heating elements and resistors, such as heat pumps, furnaces, room air conditioners, strip heaters and dryers.

Write in No. 393 on Reader Service Card

**SPACE CHAMBERS**—A brochure describing features and capabilities of walk-in space chambers has been prepared by **Tenney Engineering, Inc., Dept. S/A, 1090 Springfield Road, Union, N. J.** It illustrates a variety of applications.

Write in No. 394 on Reader Service Card

**RELAY ENCLOSURES** — A complete line of hermetically sealed and protective enclosures for relays, switches and control packages has been described in "AE Enclosures," a 32-page catalog issued by **Automatic Electric Co., Dept. S/A, Northlake, Ill.** Information includes housing sizes and shapes.

Write in No. 395 on Reader Service Card

**FURNACES** — Heat treating furnaces in which the power convection systems are applicable are discussed in bulletin SC-182 issued by **Surface Combustion Div., Dept. S/A, Toledo 1, Ohio.** Schematic flow diagrams are included.

Write in No. 396 on Reader Service Card

**MANUALS**—Capacities for the writing, illustration and publication of technical manuals and related documents have been outlined in an eight-page brochure by **Manuals, Inc., Dept. S/A, 3033 Excelsior Blvd., Minneapolis 16, Minn.** Personnel qualifications are described.

Write in No. 397 on Reader Service Card

**SYNCHRO TESTING**—A new 36-page catalog, "Test Equipment for Servo Components," has been prepared by **Theta Instrument Corp., Dept. S/A, 520 Victor St., Saddle Brook, N.J.** The line includes equipment for the measurement of the electrical characteristics of control and torque synchros, and computing resolvers.

Write in No. 398 on Reader Service Card

**POWER SUPPLY**—A static inverter-converter supply for missile and aircraft applications has been described in Bulletin S-1057, an information sheet available from **Magnetic Amplifiers, Inc., Dept. S/A, 632 Tinton Ave., New York 55, N.Y.** The unit, which operates off 28-Vdc and provides three-phase, 3200-cps power at one kva, with additional outputs at 300 and 150 Vdc, uses solid to liquid cooling.

Write in No. 399 on Reader Service Card

***more on page 280***

THOMAS A.

# EDISON

## resistance temperature detectors meet or exceed

# MILITARY STANDARDS

Edison Industries, acknowledged leader in the field of temperature measurements, offers a complete line of Military Standard Resistance Temperature Detectors having faster response speed, longer life and greater accuracy than required by the military specifications.

Designed for such applications as the measurement of cylinder head temperatures, lube oil temperatures, and rocket fuel temperatures, these rugged detectors offer unmatched accuracy, sensitivity, speed of response, and give years of maintenance-free service.

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McGRAW EDISON

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# for protection on light metals

## you need IRIDITE®

### PROCESS ENGINEERED CHROMATE CONVERSION COATINGS

1. Iridite protects against high altitude weather extremes and against corrosion by hydrocarbon fuels, such as gasoline and kerosene.
2. Iridite provides a highly protective non-porous paint base.
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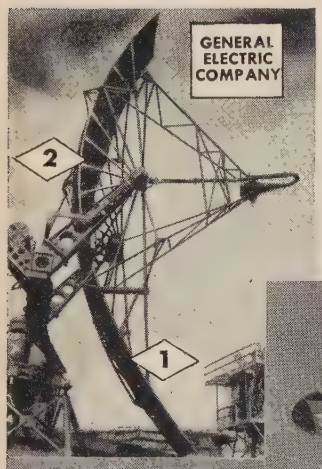


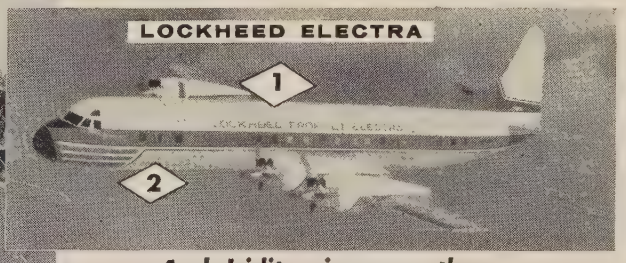


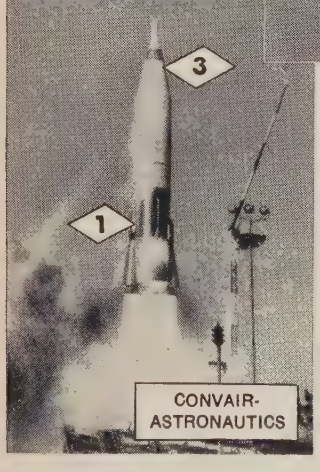


***And, Iridite gives you these additional advantages:***

**ON ALUMINUM**—needs only normal precleaning. Film withstands cold forming or bending. Easily heliarc welded. Unusually low electrical resistance. Clear, yellow or dye-colored finishes.

**ON MAGNESIUM**—short immersion, room temperature solution, no electrical equipment. Corrosion protection relatively unaffected by high drying temperatures. Applicable to all alloys. Low electrical resistance. Color ranges from light gray to dark brown.

**IRIDITE**—a specialized line of chromate conversion coatings for non-ferrous metals. Easily applied at room temperatures with short immersion, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel; special equipment, exhaust systems or highly trained personnel not required.

**For complete information on Iridite, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILES.**

**Iridite is approved under government and industrial specifications.**

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*Chemical and Electrochemical Processes, Anodes, Rectifiers, Equipment and Supplies for Metal Finishing*

IRIDITE® Chromates | IRILAC® Coatings | ISOBRITE® Brighteners | ARP® Supplies | WAGNER Equipment

**Write in No. 270 on Reader Service Card at start of Product Preview Section**

## DATA PREVIEW

**SELF-LOCK NUTS**—A guide to selection of self-locking nuts suitable for application at elevated temperatures of more than 800 deg F is contained in catalog No. 5918 prepared by **Elastic Stop Nut Corp. of America, Dept. S/A, 2330 Vauxhall Road, Union, N. J.** It contains technical data, terminology, stress rupture, creep, and relaxation strength.

Write in No. 400 on Reader Service Card

**FACILITIES**—A brochure describing the organization, function, and chemical milling processes has been issued by the **Chemical Contour Corp., Dept. S/A, 16627 So. Avalon Blvd., Gardena, Calif.** It discusses coating, scribing, etching, and similar information.

Write in No. 401 on Reader Service Card

**PUMP MOTORS**—General purpose jet pump motors from ⅛ through 2 horsepower are discussed in Bulletin GEA-5902D issued by **General Electric Co., Dept. S/A, Schenectady 5, N. Y.** It gives ratings, dimensions, and construction details, and reviews insulation, wire, protected shaft, switch, ventilation, and size.

Write in No. 402 on Reader Service Card

**CONTROLS**—Information about thermocouples, control instruments, control elements, control systems and special systems is contained in bulletin GER-1206 issued by **General Electric Co., Dept. S/A, Schenectady 5, N. Y.** It discusses all phases of temperature control, listing definitions and basic types.

Write in No. 403 on Reader Service Card

**SUPERALLOYS**—Performance data on vacuum induction superalloys are contained in technical bulletins issued by **Kelsey-Hayes Co., Metals Div., Dept. S/A, New Hartford, N. Y.** They provide description and chemical composition, physical constants, tables and charts on mechanical properties, isostress curves and information on heat treatment and finishing.

Write in No. 404 on Reader Service Card

**SHIMS & GASKETS**—A "Ready Reference" card on gaskets, shims, packings, washers, seals, "O" rings, and bushings has been prepared by **General Gasket, Inc., Dept. S/A, Middletown, Conn.** The card lists various gauges matched to identifying colors.

Write in No. 405 on Reader Service Card

**METALLURGY**—A "Basic Guide to Ferrous Metallurgy" has been prepared by **Tempil Corp., Dept. S/A, 132 W. 22 St., New York 11, N. Y.** It discusses the working zones, including preheating for welding, stress relieving, normalizing, annealing, carburizing and forging. A chart of common terms is included.

Write in No. 406 on Reader Service Card

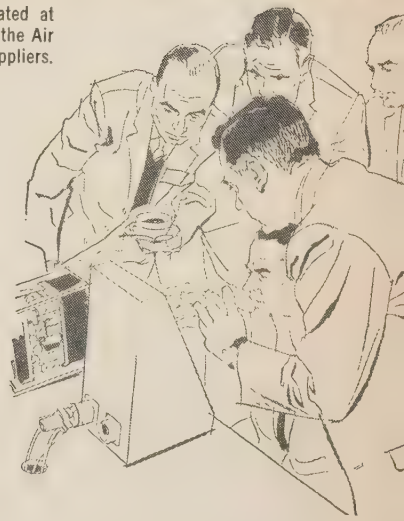
***more on page 282***



**Write in No. 271 on Reader Service Card ➡**

## Knowmanship in Action

Much that was new and informative was discussed and demonstrated at Eclipse-Pioneer's recent cost conference held with representatives of the Air Force, Republic Aviation, and over 50 of E-P's subcontractors and suppliers.



*Bendix cost conference reports*

# IMPORTANT PASS-ALONG SAVINGS

*on F-105D Air Data and Instrumentation Systems*

pelled out to E-P vendors were dvanced techniques that shaved gnificant dollars from the manu- cturing costs of Air Data Computer ystems and Vertical-Scale Instru- ents for the USAF's Republic-built -105D Thunderchief.

bjective was to stimulate E-P's ven- r organization into similar types of st reduction effort.

he successful E-P cost-saving tech- que presented was the use of "elec- onic instructors" on the assembly floor. These novel audio-visual aids —individually controlled by each assembly worker to his own learning rate—reduced lead man requirements by 80%, cut learning time in half. Another technique discussed was the replacement of point-to-point wiring with prefabricated harnesses to improve quality, reduce assembly time.

Other savings noted came from the use of close-range slow-motion pictures to seek out "lost motion" in assembly operations, from the use of tool standardization and material handling innovations, and from the use of standardized data. All added up to an effective demonstration of how E-P KNOWMANSHIP has saved—and is continuing to save—money for Republic, the Air Force, and the taxpayers.

This practical, hard-boiled E-P approach to getting more equipment-per-dollar is another important benefit of KNOWMANSHIP. To find out how it can work to *your* advantage in any of the product areas listed below, call, wire or write us today.

TECHNICAL KNOWLEDGE + EXPERIENCED MANAGEMENT + SPECIALIZED CRAFTSMANSHIP = **KNOWMANSHIP**

THE Bendix CORPORATION

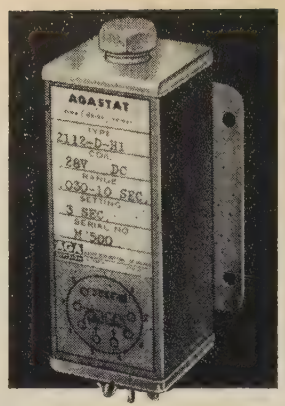
## Eclipse-Pioneer Division

TETERBORO, N. J.

AUTOMATIC FLIGHT CONTROLS • CENTRAL AIR DATA SYSTEMS • SPECIALIZED INSTRUMENTATION • NAVIGATION COMPUTERS AND DIRECTORS • STABLE PLATFORMS • INERTIAL GUIDANCE • RADAR ANTENNA STABILIZATION AND TRACKING SYSTEMS • GROUND SUPPORT EQUIPMENT

# NEW MINIATURE AGASTAT® time delay relay

*for missile, aircraft and electronic applications*




INSTANTANEOUS RECYCLING . . . reset time—less than .020 seconds

UNAFFECTED BY VOLTAGE VARIATIONS . . . time delay remains constant from 18 to 30 volts DC

ADJUSTABLE . . . time delays from .030 to 120 seconds

CHOICE OF OPERATION . . . for either energizing or de-energizing

SMALL . . . height—4⅝". . . width—1 13/16". . . depth—1½"

LIGHT . . . maximum weight—15 ounces

MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit built to withstand the rugged environmental conditions of missile and aircraft applications.

For specific information on the new AGASTAT relay for your application, write to Dept. A30-619

**AGASTAT TIMING INSTRUMENTS**

**ELASTIC STOP NUT CORPORATION OF AMERICA**
1027 NEWARK AVENUE, ELIZABETH 3, NEW JERSEY

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# NEW Electro Magnetic Pickups

# BREAK THROUGH HIGH TEMP. BARRIER

**. . . operate from −300° to +800° F.**

**3100 series pickups safely withstand extreme heat**

- inside compressor chambers of jet engines.
- in high temperature flow meters.
- under extremely hot oil during thermostat testing.
- in missiles where extreme temperatures are a problem.

**A self-generating frequency source . . .**
pickups convert mechanical energy to frequency/voltage in proportion to speed of ferrous metal objects interrupting their magnetic fields. Need no physical contact with exciting metal.

Write for Data Sheet 3110-20 and literature on complete line

**ELECTRO PRODUCTS LABORATORIES**
**4501-C North Ravenswood, Chicago 40**
Canada: Atlas Instrument Corp., Ltd., Toronto, Ontario

0162

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## DATA PREVIEW

**OXYGEN SEMI-TRAILER** — A semi-trailer for transport of liquid oxygen, nitrogen or argon is described in a folder, F-1266, issued by **Linde Co., Dept. S/A, 30 E. 42 St., New York 17, N. Y.** It contains information on design features, performance data and specifications.

Write in No. 407 on Reader Service Card

**SWITCHES**—Precision-built switches, relays and gravity sensing potentiometers are the devices thoroughly described in the 1960 Catalog prepared by **Hamlin, Inc., Dept. S/A, Lake & Grove Sts., Lake Mills, Wisc.** Typical applications are included for tilt mercury switches, dry reed switches and relays, and switches with mercury wetted contacts.

Write in No. 408 on Reader Service Card

**HYDRAULIC CYLINDERS** — A nomogram for use in the design of hydraulic cylinders has been developed by **Ground Systems, Inc., Dept. S/A, 9752 Cortada Ave., El Monte, Calif.** It is used to determine proper cylinder size for a given load, system pressure, and rod diameter.

Write in No. 409 on Reader Service Card

**CONTROL SYSTEM**—Basic engineering data on a completely closed, hydraulic system for remote motion control or duplication are offered in a catalog available from **Hydronic Corp., Dept. S/A, 12685 Arnold, Detroit 39, Mich.** Dimensions, accessories, installation and applications are considered.

Write in No. 410 on Reader Service Card

**DIGITAL SUBSYSTEMS**—A 4-page, illustrated folder on Functionally Packaged Digital Subsystems has been published by **Servomechanisms, Inc., Dept. S/A, 12500 Aviation Blvd., Hawthorne, Calif.** The folder points out the versatility of miniature Digital Building Blocks as elements of digital subsystems.

Write in No. 411 on Reader Service Card

**PUMP CURVE** — A three-color composite curve, which shows the relative head-capacity and performance of Chempump sealless pumps, is available from **Chempump Div., Fostoria Corp., Dept. S/A, P.O. Box 35-10, Huntingdon Valley, Pa.** The curve serves as a guide to specific model performance curves.

Write in No. 412 on Reader Service Card

**FILTERS**—Porous stainless steel filters are described in bulletin M-212A issued by **Pall Corp., Micro Metallic Div., Dept. S/A, 30 Sea Cliff Ave., Glen Cove, N. Y.** It describes the properties, gives full specifications, and detailed technical data.

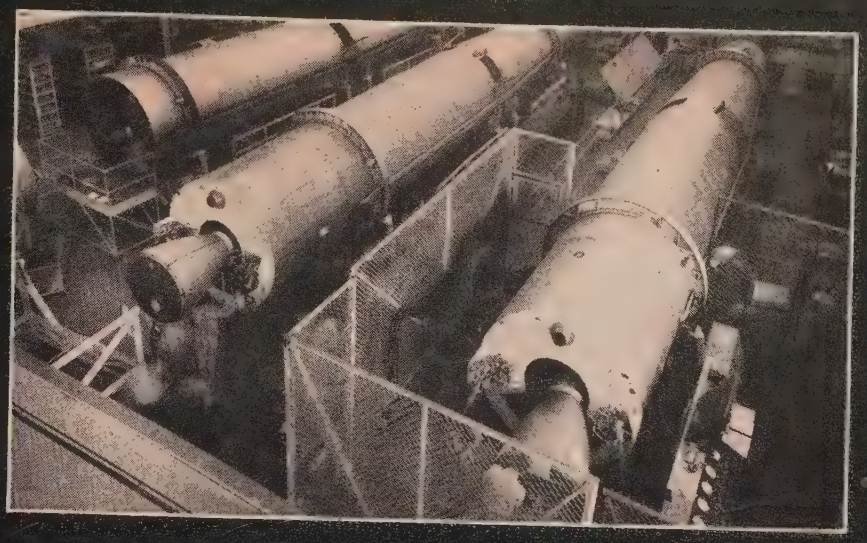
Write in No. 413 on Reader Service Card

*more on page 284*

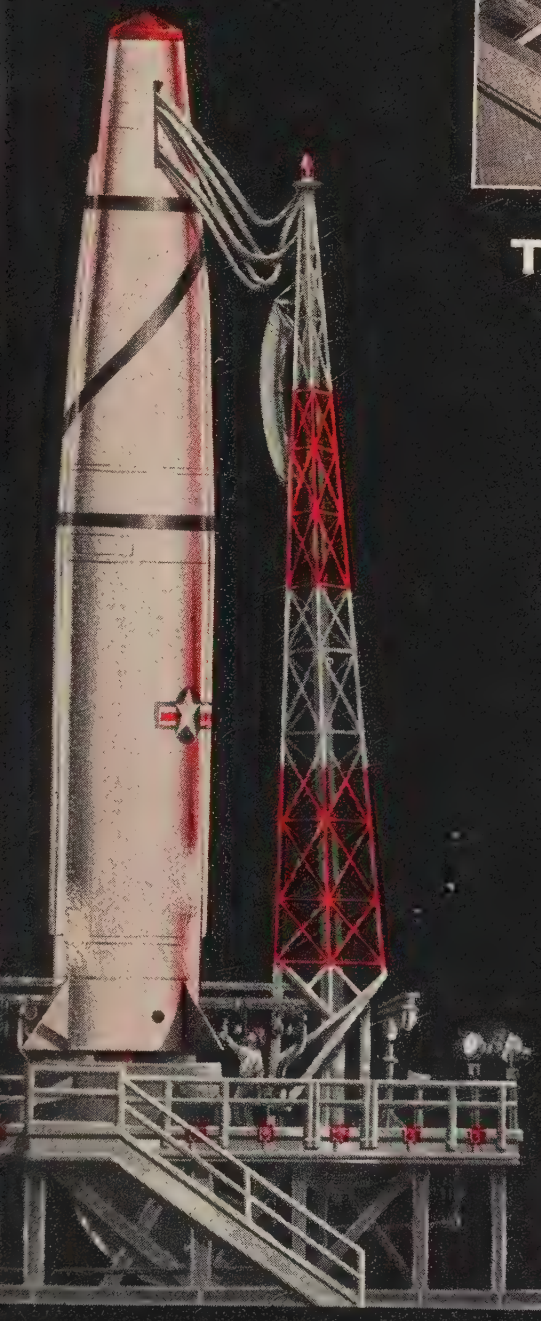


Write in 274 on Reader Service Card →

# OPERATIONAL under two flags...



## THOR DETERS AGGRESSION



Now rolling from assembly lines in the U.S.A. and being deployed by our ally, Great Britain, is the aggressor-deterring, nuclear-armed THOR missile. Exceptional reliability has been achieved in this IRBM missile through simplicity of design and dependability of components.

Vickers pumps were selected for the vital hydraulic system on the THOR because of their proven reliability record, based upon millions of flight hours in military and commercial aircraft. Vickers-built components or complete auxiliary power systems are aboard nearly every missile built in America.

For the future, Vickers is working side by side with contractors, such as Douglas on new and revolutionary APU concepts for missiles and spacecraft of the next generation.

Your nearby Application Engineer can "fill you in" on the latest and most promising of these Vickers developments. Write for Bulletin A-5233A

*Vickers Main System Hydraulic Pump being installed on THOR*

AERO HYDRAULICS DIVISION

**VICKERS INCORPORATED**

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COMPLETE CAPABILITY

# HEAT EXCHANGERS

Advanced-type HMA cold-plate heat exchangers are setting new standards of superior performance at low over-all costs. Greater effectiveness and lighter weight... reasons why compact, highly-producible HMA air-heat sinks are a popular choice for more efficient heat transfer. Also, HMA customers get single source responsibility, as HMA designs, manufactures (including dip-brazing) and tests in its newly-expanded facilities. Precision units can be supplied to meet your specific requirements.

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**Torrance, California / SPruce 5-1211**

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## DATA PREVIEW

**TWO-WAY VALVES**—Bulletin 91022 describes the series 20 line of two-way valves for air, oil, water, gas or chemicals, issued by **Airmatic Valve, Inc., Dept. S/A, 7313 Associate Ave., Cleveland 9, Ohio.** It supplies specifications, features and dimensions.

Write in No. 414 on Reader Service Card

**PRINTED CIRCUITS** — Miniaturized printed circuits is the subject of Technical Bulletin P-5a issued by **Photocircuits Corp., Dept. S/A, 31 Sea Cliff Ave., Glen Cove, N. Y.** It is intended for design engineers and draftsmen.

Write in No. 415 on Reader Service Card

**TUBE FORMING** — Engineering data and other information on the fabrication of Tight Bend tubes have been presented in the eight-page Aircraft Engineering Bulletin 25, available from **Aeroquip Corp., Dept. S/A, Jackson, Mich.** Bends are formed through a cold process method to short radius bends of 1:1 ratio or less.

Write in No. 416 on Reader Service Card

**ALUMINUM** — Use of aluminum in different types of military applications is discussed in a report issued by **Kaiser Aluminum & Chemical Corp., Dept. S/A, Kaiser Bldg., 1924 Broadway, Oakland 12, Calif.** It is heavily illustrated and contains technical data and general information and descriptions.

Write in No. 417 on Reader Service Card

**RELAYS** — Compact design, lightweight, reliability and economy are featured in a line of general-purpose relays described in Bulletin 99, a data sheet issued by **Artisan Electronics Corp., Dept. S/A, 171 Ridgedale Ave., Morristown, N.J.** Facts on plate circuit relays are included.

Write in No. 418 on Reader Service Card

**THEODOLITES**—A series of azimuth alignment theodolites are described in a brochure issued by **Perkin-Elmer Corp., Dept. S/A, Norwalk, Conn.** It contains operational features, accessories and specifications.

Write in No. 419 on Reader Service Card

**MOTORS & ACTUATORS**—A variety of products, including ac and dc motors, linear and rotary actuators, turbine controls and electro-mechanical systems, and their application to aircraft and missiles have been covered in a 36-page combination facilities and products report available from **Electronic Specialty Co., Dept. S/A, 4612 W. Jefferson Blvd., Los Angeles 16, Calif.** Catalog EE-100 contains a complete section on standard EEMCO motor frame sizes.

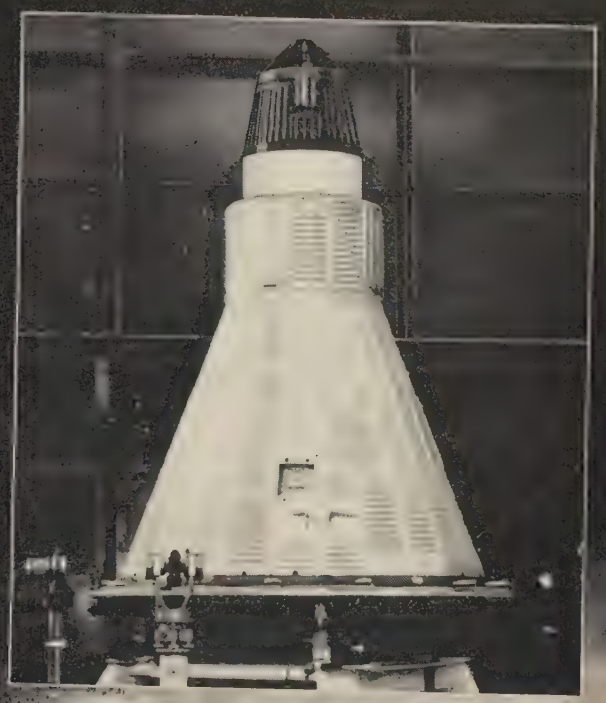
Write in No. 420 on Reader Service Card

*more on page 286*

SIGNIFICANT ADVANCES IN BERYLLIUM TECHNOLOGY COME FIRST FROM BRUSH

# FORGING INTO SPACE

**Beryllium heat sinks are being readied for test flights.**



Right now scientists and engineers from the National Aeronautics and Space Administration and McDonnell Aircraft are working toward the day when the first American will ride into space to orbit the earth.

How do beryllium and Brush fit into the Project Mercury manned space flight effort? A beryllium heat sink is one of two ways being tested to protect the precious human payload from re-entry heat. Beryllium absorbs tremendous heat, is light, yet maintains strength at high temperature. And Brush developed new techniques to produce the world's largest beryllium forgings for use as heat sinks in the tests to determine the final design of the manned space capsule.

Beryllium offers the solution to many 'space age' application problems. Brush will continue to take the lead in producing beryllium in new forms by new techniques for new uses.

Can this metal, its alloys, its oxide, or our expanding experience with these versatile materials solve a problem for you? Let us try. Contact us at 5209 Euclid Avenue or ENdicott 1-5400 in Cleveland, Ohio.

## THE BRUSH BERYLLIUM COMPANY

Write in No. 276 on Reader Service Card at start of Product Preview Section

BEST WAY TO SEAL HOLES!

LEE PLUG

Simply place plug in reamed hole. Drive in tapered pin until ends are flush. Controlled expansion causes grooves to "bite" into casting, assures a bone dry seal that withstands pressures up to 40,000 psi. Now widely used on aircraft and missiles, and for pumps, servo valves, regulators, etc.

*Pat. #2,821,323

LEE COMPANY
OLD SAYBROOK, CONN.

WRITE TODAY FOR COMPLETE ENGINEERING DATA

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## DATA PREVIEW

**REMOTE GYRO** — A remote vertical gyro indicating system is described in a brochure issued by **Lear, Inc., Dept. S/A, P. O. Box 688, Grand Rapids 2, Mich.** It contains engineering data, drawings, and general information.

Write in No. 421 on Reader Service Card

**SEMICONDUCTORS**—An 8-page catalog of diodes and capacitors is announced by **Topp Industries, Inc., U.S. Semiconductor Products Div., Dept. S/A, 3540 West Osborn Rd., Phoenix, Arizona.** There are many additions and changes in this new green catalog.

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**CONTROLS**—A "Guide to Industrial Electrohydraulic Servo Components and Systems," bulletin 110, has been prepared by **Moog Servocontrols, Inc., Dept. S/A, Proner Airport, East Aurora, N. Y.** It includes description, types and applications, diagrams and drawings.

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**RELAYS**—A 20-page catalog has been prepared to present the relay line of **Magnecraft Electric Co., Dept. S/A, 3352 W. Grand Ave., Chicago 51, Ill.** Catalog 159 includes charts on coil data, contact code, and operate and release time.

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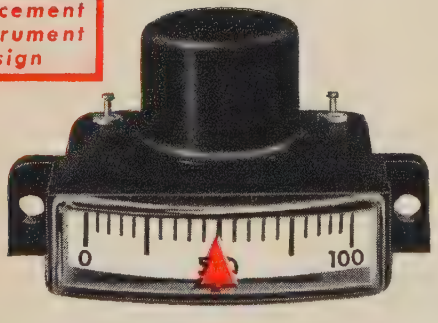
advancement in instrument design

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Large, easily read display (1 7/16" scale) in only 9/16" x 1 7/8" panel space. For horizontal or vertical mounting. Miniature, self-shielded Coaxial mechanism has stability and durability of larger instruments. Weight 1.7 oz. Supplied with combination mounting bracket and bezel (not shown). Data on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, New Hampshire, U.S.A. *In Canada, Honeywell Controls Limited, Toronto 17, Ontario.*

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## in this zone, stainless steels that remain ductile with high strength and stability

In the search for favorable strength-to-weight ratio, high temperature alloys have been developed with extreme strength up to 1000 F, but at the expense of ductility.

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These advantages are followed by easy formability using normal techniques. AM 350 and AM 355 can be brazed and welded as easily as the common stainless steels. They can be spun, formed and machined without special preparation.

AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Penna.**

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# ALLEGHENY LUDLUM

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# CORROSION PROBLEMS:

## can moly metal's resistance to mineral acids solve them for you?

The following tables show molybdenum's resistance to corrosion by mineral acids, providing oxidizing agents are not present. They also indicate molybdenum's superiority to conventional materials used in handling these acids.

### *hydrochloric acid*

| % HCl | temperature, F | aerated | corrosion rate, mils/year* unalloyed molybdenum | 14% Si – 3% Mo iron | 70% Ni – 30% Mo alloy |
|---|---|---|---|---|---|
| 5 | room | yes (air) | 0.40 | – | 7.8 |
| | | yes (oxygen) | 0.27 | – | – |
| | 160 | no | 1.1 | 18. | 13. |
| | | yes (oxygen) | 1.4 | 17. (air) | 25. (air) |
| | boiling | no | 3.6 | 79. | 13. |
| 20 | room | yes (air) | 0.10 | – | 3.1 |
| | 160 | no | 0.58 | 35. | 9.2 |
| | | yes (oxygen) | 1.4 | 53. (air) | 24. (air) |
| | boiling | no | 0.90 | 230. | 27. |
| 37 | room | yes (air) | 0.16 | – | 1.6 |

*average of five 48-hr periods

### *hydrofluoric acid*

| % HF | temperature, F | aerated | corrosion rate, mils/year* unalloyed molybdenum | 70% Cu – 30% Ni alloy |
|---|---|---|---|---|
| 25 | room | no | 0.13 | 2.6 |
| | | yes (air) | 0.22 | – |
| | 212 | no | 3.1 | 55. |
| | | yes (air) | 20. | – |
| 49 | room | no | 0.14 | 4.1 |
| | | yes (air) | 0.08 | – |
| | 212 | no | 2.3 | 75. |
| | | yes (air) | 16. | – |

*average of five 48-hr periods

### *phosphoric acid*

| $\%H_3PO_4$ | temperature, F | aerated | corrosion rate, mils/year* unalloyed molybdenum | type 316 stainless steel | 70% Ni – 30% Mo alloy |
|---|---|---|---|---|---|
| 10 | room | yes (air) | 0.27 | nil to 0.18** (oxygen) | 1.7 |
| | 212 | no | 2.4 | nil to 0.18** | 24. |
| | boiling | no | 1.3 | nil to 6.7** | 19. |
| 50 | room | yes (air) | 0.25 | nil to 0.06** (oxygen) | 0.40 |
| | 212 | no | 1.5 | 1.7 | 2.5 |
| | boiling | no | 1.5 | 5.4 | 7.1 |
| 85 | room | yes (air) | 0.20 | nil to 0.80** (oxygen) | 0.16 |
| | 212 | no | 0.29 | 20. | 0.83 |
| | boiling | no | 1.4 | 770.*** | 1.9 |

*average of five 48-hr periods
**range of five 48-hr periods
***one 48-hr period only

### *sulfuric acid*

| $\%H_2SO_4$ | temperature, F | aerated | corrosion rate, mils/year* unalloyed molybdenum | 14% Si iron | 14% Si – 3% Mo iron |
|---|---|---|---|---|---|
| 10 | 160 | yes (nitrogen) | 0.22 | – | – |
| | | yes (air) | 1.4 | – | – |
| | | yes (oxygen) | nil to 9.1** | – | – |
| | boiling | no | 6.6 | – | – |
| | 400 | no | 0.77 | – | – |
| 20 | 160 | yes (nitrogen) | 0.18 | – | – |
| | | yes (air) | 0.82 | – | – |
| | | yes (oxygen) | nil to 3.4** | – | – |
| | 400 | no | 3.7 | – | – |
| 40 | 160 | no | 0.74 | 11. | 2.9 |
| | | yes (air) | nil to 0.90** | 10.0 | – |
| | | yes (oxygen) | nil to 1.4** | – | – |
| | boiling | no | 1.5 | 14. | 6.7 |
| 50 | 160 | no | 0.52 | 3.4 | 0.36 |
| | | yes (air) | nil to 0.52** | 2.3 | – |
| | boiling | no | 2.5 | 5.9 | 1.6 |
| 75 | 160 | no | 0.70 | 0.13 | 0.20 |
| | | yes (air) | nil to 0.15** | nil | – |
| | boiling | no | 34. | 0.26 | 0.68 |
| 95 | 160 | no | 0.12 | 0.02 | 0.28 |
| | | yes (air) | nil to 0.21** | 0.36 | – |
| | boiling | no | dissolved | – | – |

*average of five 48-hr periods
**range of five 48-hr periods

Molybdenum also offers good long-term resistance to attack by liquid metals up to the temperatures given: bismuth (2600 F), gallium (570 F), lead (2190 F), lithium (1650 F), magnesium (1290 F), mercury (1110 F), potassium (1650 F), sodium (liquid and vapor) (1650 F), sulfur (825 F) – and a number of alloys of these and other metals.

FORGING BILLETS OF CLIMELT MOLYBDENUM METALS AND CLIMELT MOLYBDENUM-BASE ALLOYS ARE NOW PROMPTLY AVAILABLE IN STANDARD STOCK SIZES OF 4⅛", 5½", 6", 6½" AND 7" DIAMETERS. BAR STOCK IS MAINTAINED IN A RANGE OF SIZES UP TO 4" DIAMETER.

**For complete data, send for these free manuals: "Corrosion Resistance of Molybdenum and Molybdenum-Base Alloys" (24 pages), "Molybdenum Metals" (110 pages), and "Climelt Molybdenum and Molybdenum-Base Alloys" (24 pages). Write:**

CLIMAX MOLYBDENUM

**CLIMAX MOLYBDENUM COMPANY**

*A division of American Metal Climax, Inc.*/1270 Avenue of the Americas, New York 20, N.Y.

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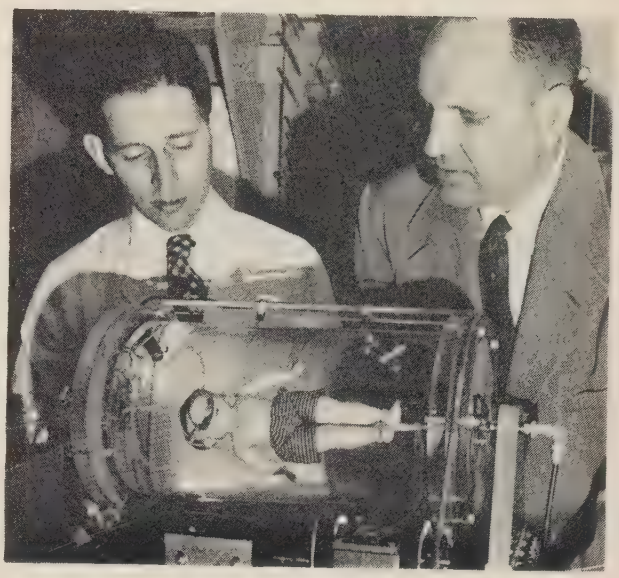
**AVCO ARC-JET** rocket is checked out for recent 47-hour run in a near-vacuum. It produced almost ¾ lb thrust in this run at a specific impulse of 1000 seconds. The input power was about 30 kw. Avco calculated that, with this performance, its engine would give a 1000-lb orbiting space craft a speed increase of 4000 fps.

**AIRBORNE DMET SETS,** to be used for VORTAC navigation, are coming off the line at ITT's Federal Div., Clifton, N. J. Here circuits of the completed outer frames are being checked.

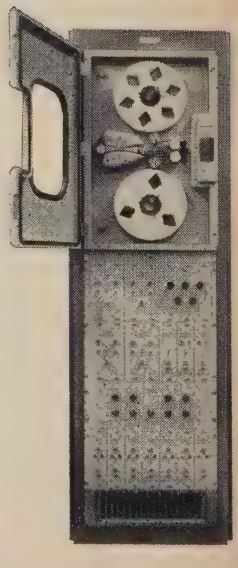
**"NULL-GRAVITY** simulator" being built at Lockheed-Georgia essentially is a rapidly rotating tank of water. It will be used to simulate weightlessness for much longer periods than have been achieved up to now. Major difference between the doll in this scale model and the human occupants of the full-size tank will be the men's skin diver suits.



**Solar Aircraft** became a subsidiary of International Harvester through an exchange of one IH share for 2¼ share of Solar stock. . . . **Electro-Optical Systems** completed a $1 million R&D lab at Pasadena, Calif. The lab's activities will include development of an ion propulsion engine for space vehicles and satellite control mechanisms and work on molecular electronics, exploding-wire techniques, optical homing and guidance systems, high speed switching techniques, solid-state transducers, and space defense systems. . . . **Hughes Aircraft** set up Microwave Tube and the Vacuum Tube Products Division to develop and produce commercial vacuum-tube devices. Dr. L. M. Field heads the microwave group; J. J. Sutherland is in charge of the vacuum tube group.

*applied ingenuity in magnetic tape instrumentation*

## CAPTURING THE THIN VOICE FROM SPACE



. . . or capturing vital data for nuclear operational control, environmental simulation testing, missile power plant evaluation, ground control and check-out, or a host of important military and commercial functions — *Telectro Magnetic Tape Instrumentation* records accurately and reproduces faithfully . . . meets or exceeds stringent military specifications. The Telectro 14 Channel Recorder/Reproducer shown at right is a good example of the use of modular design techniques to create a system that functionally and physically best meets exacting data-recording needs of present-day scientific and engineering projects. Telectro Industries stands ready to apply its ingenuity to solve your special problems in Magnetic Tape Instrumentation. Write to the Military Products Division.

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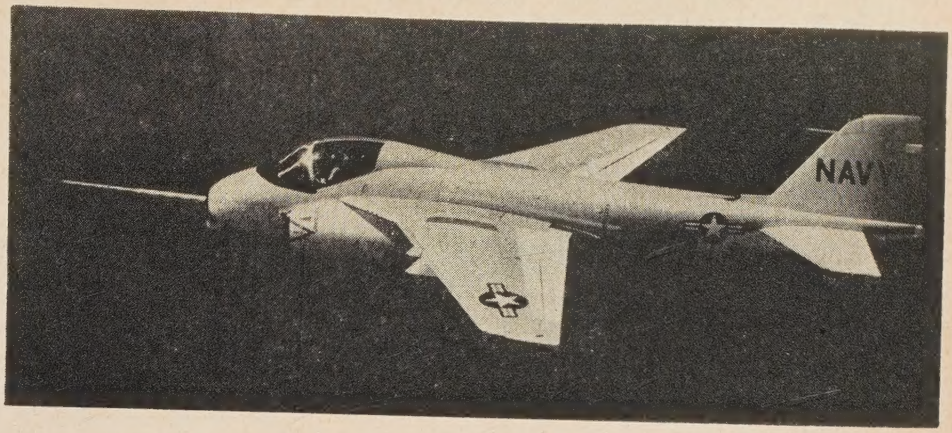
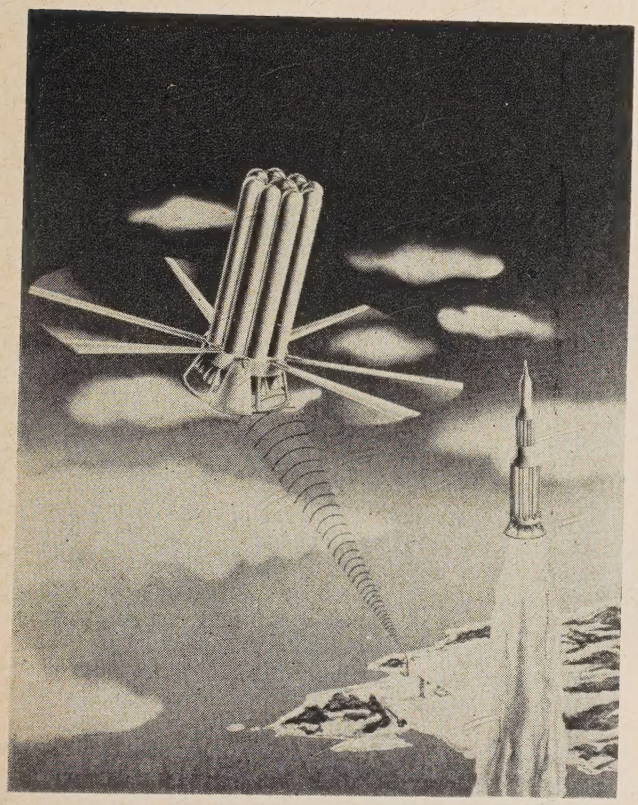
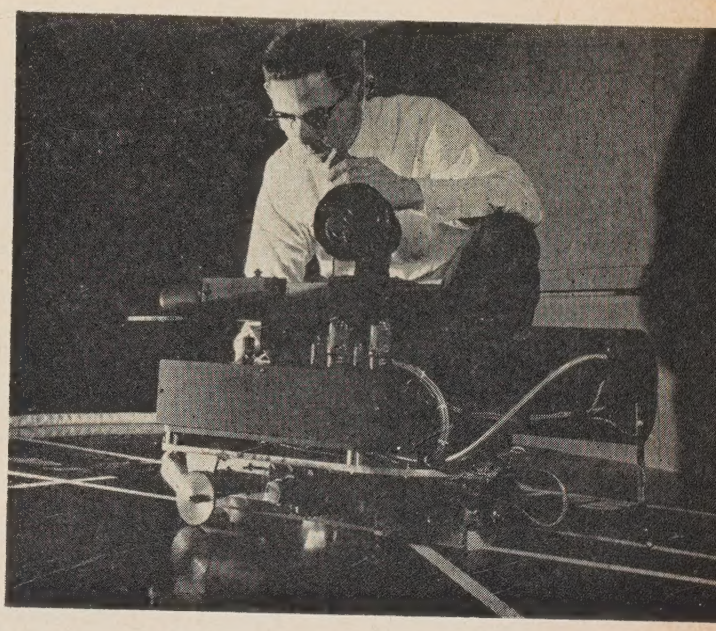



**LATEST** Navy attack bomber is the Grumman A2F-1 Intruder, which will be able to score on targets made completely invisible by weather or darkness. Two P&WA J52 jets deliver 8500 lb thrust each.



**ROTOR SYSTEM** "basically comparable" to that of a copter has been proposed by Bell Helicopter for the recovery of spacecraft boosters.

**"BUG" RADAR** scanner designed by Boeing-Wichita engineer Paul Buriss is used together with the B-52 low altitude flight simulator.



**National Research** set up a "space vacuum lab" at Cambridge, Mass., to provide ultra-high vacuum testing for missile and space vehicle programs. Dr. John C. Simons, director of the company's Applied Physics Department, is in charge of the new lab. . . . **Kollsman Instrument** acquired Richardson-Allen as a wholly-owned subsidiary manufacturing silicon rectifiers and transformers. Kollsman itself is a subsidiary of Standard Coil Products. . . . **Northrop** bought American Radiator & Standard Sanitary's Military Products Division. This organization's three plants at Norwood, Mass., will operate as the Precision Products Department of Northrop's Nortronics Diivsion. Dr. William F. Ballhaus, vice president and general manager, will direct the department.

# Making use of commuting time

by A. N. Baxter

A SURVEY SHOWS that a lot of people who have a technical education spend a total of about one hour a day commuting between home and work. Without planning, this hour can be profitless and frustrating. During a year, this hour is equivalent to the number of contact hours during five three-unit university courses.

Here are a few techniques and equipment to put these idle hours to work.

The dawn of the TV era was thought by some to be the death of the radio age. But today's radio audience probably is larger than before. Millions listen to repetitious commercials while driving. To combat this waste of time, the medical profession is making effective use of magnetic recordings. Articles and lectures are recorded and rented to members of an organized, mobile audience, each carrying a small tape recorder, energized by his car battery. Thus the busy M.D. can keep abreast of current events concerning his specialty by *listening while driving*. Other organizations record lectures by outstanding men in fields other than the medical.

We of the technical profession can follow suit. For example, I am using a prototype system consisting of:

- a combination magnetic tape recorder-transcriber, which remains at home;
- a car-battery-operated playback unit;
- an electric intervalometer.

The recorder-transcriber is used as follows:

- voice recordings are made of technical information, classical literature, or current events, etc.
- The recorder-transcriber is connected to my FM hi-fi system, which is switched on and off by the preset intervalometer.

I make recordings (at odd hours) of a subscription-type FM radio station (recently added in the Los Angeles area). This "no-commercials" station is sustained by voluntary subscriptions from listeners. Its programs include general talks on scientific matters, panel discussions by authorities on controversial issues and people, comments on world situations, etc.

I replay the taped information, as many times as I want to, while I travel (or wait) in my car. Other uses of this system include: learning a language; improving one's use of English by hearing correct spelling, pronunciation and application; preparing lectures and talks (the lecturer records and criticizes his own speech); listening to recorded correspondence (many people are corresponding by tape-recorded letters).

In the offing are subscription phone services that offer condensed, current-event information, *pertinent only to the subscriber's field of interest or business*. The data presented by such a service are gleaned from journals, periodicals, press releases, etc. A newscast can be heard by dialing the service and presenting proper identification. (Printed newscasts are later mailed to the subscriber.)

## Keep in constant touch with staff

Another useful device is the miniaturized dictating machine. It makes it possible to be in constant touch with one's staff and supervision. Here's how you use it:

- Carry a Robinson Reminder or equivalent; write ideas down when they occur.
- During your spare time, dictate AVCs (Avoid Verbal Communications), formal or informal memos, letters, instructions, etc.
- Turn in the recording to secretary or Ediphone department for transcription and distribution.

This method places in the hands of the people with whom you wish to communicate a written explanation of your idea. It leaves no room for misrepresentation or oversight.

And when can you dictate? While driving, of course! I have spent several hundred hours dictating while driving. (Most of this article was dictated while driving in busy Los Angeles traffic and suburban mountain roads.) Not once has there been so much as a near-accident, nor a failure to observe traffic rules. The subconscious mind enforces deeply ingrained habits, probably making dictating less dangerous than smoking while driving.

Good use of portable dictation machines can be made aboard planes, trains, in waiting rooms, hotels, etc. That trip report that is so often late, incomplete, or garbled, is easy to write when notes, activities, and agreements are recent history. By proper use of the microphone and input level, background noise can be essentially eliminated, while recording in levels so high that you cannot hear your own voice. (Throat mikes also are excellent in high noise levels.) Of course, the writer should observe other rules for good dictation. Before dictating a lengthy report, an outline should be made, preferably on cards.

Contributions to this department may be on any subject technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

*From an original painting for CECO by R. T. Handville*

**Contributing to the superb performance . . .** of each Ryan Q-2C Firebee is a Continental J-69 turbojet equipped with single-package *engine control and fuel pump* engineered and precision-produced by Chandler Evans.

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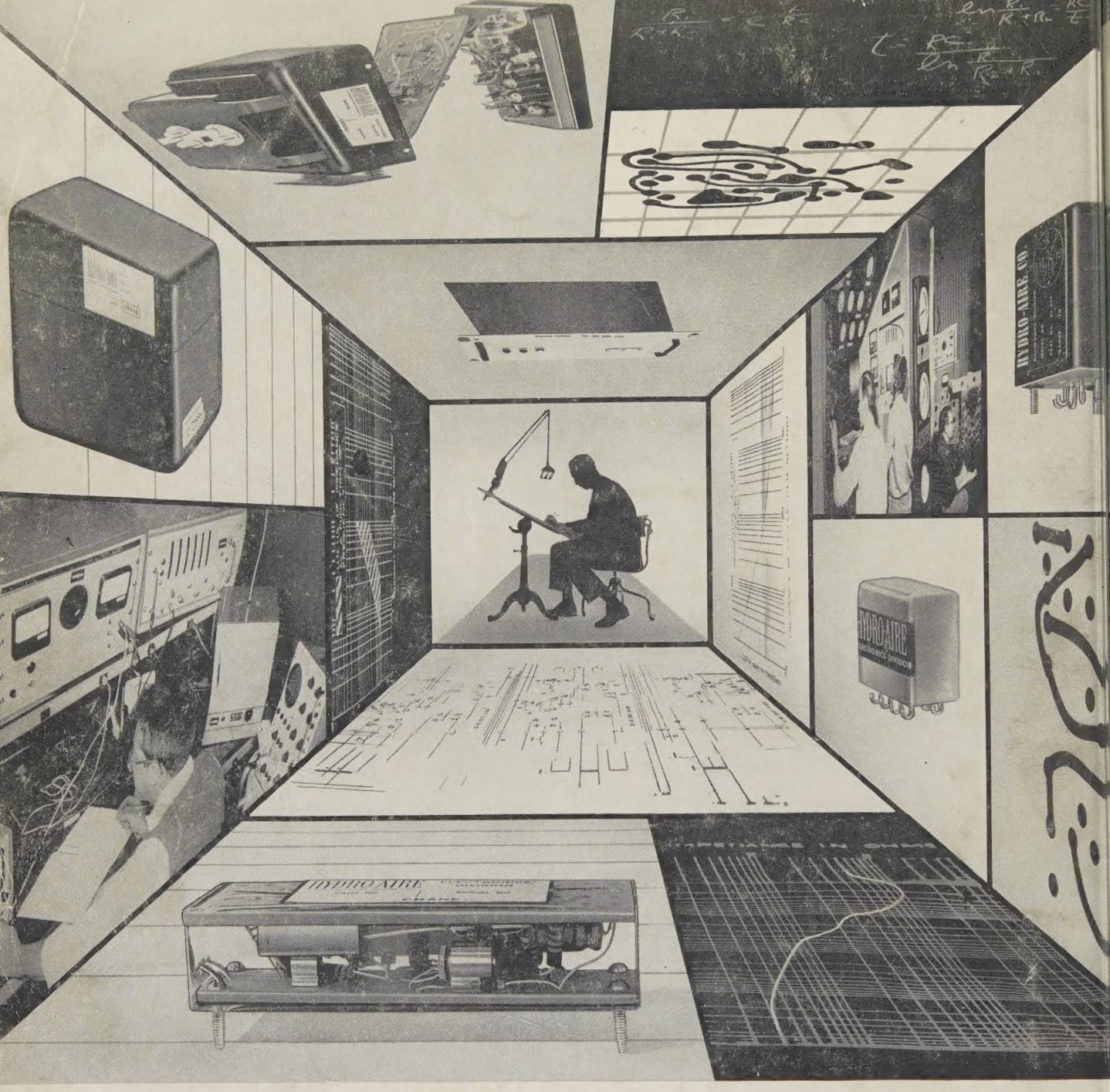


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For a prompt answer to your inquiry, write Electronics Division, Hydro-Aire, 3000 Winona Avenue, Burbank. A note on your letterhead brings your copy of our new Electronics Brochure.

*Qualified Electronics Engineers are invited to investigate opportunities at Hydro-Aire by contacting Mr. Harold Giesecke.*

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